525 Rec'd PCT/PTO 29 NOV 2000

FORM PTO-1390 REV. 5-93 US DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE **TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371**		ATTORNEYS DOCKET NUMBER P00,1862 U.S.APPLICATION NO. (if known, see 37 CFR 1.5) 09/701668
INTERNATIONAL APPLICATION NO. **PCT/DE99/01316**	INTERNATIONAL FILING DATE 3 May 1999	PRIORITY DATE CLAIMED 29 May 1998

TITLE OF INVENTION
"METHOD AND RADIO STATION FOR SIGNAL TRANSMISSION IN A RADIO COMMUNICATION SYSTEM"

APPLICANT(S) FOR DO/EO/US
Jörg DAUERER, Dieter EMMER, Peter MERZ, Jörg MONSCHAU, Jörg SOKAT, Peter WEBER and Henry WIECHERT

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay.
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of International Application as filed (35 U.S.C. 371(c)(2))
   a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. §371(c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).)
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C.371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98; **(PTO 1449, Prior Art, Search Report).**
12. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 C.F.R. 3.28 and 3.31 is included. **(SEE ATTACHED ENVELOPE)**
13. ☒ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information:
    a. ☒ Submittal of Drawings
    b. ☒ **EXPRESS MAIL #EL 655299342US, dated November 29, 2000.**

525 Rec'd PCT/PTO 29 NOV 2000

U.S. APPLICATION NO. (if known, see 37 C.F.R. 1.5) 09/701668	INTERNATIONAL APPLICATION NO. PCT/DE99/01316	ATTORNEY'S DOCKET NUMBER P00,1862

17. ☒ The following fees are submitted:

	CALCULATIONS	PTO USE ONLY
BASIC NATIONAL FEE (37 C.F.R. 1.492(a)(1)-(5): Search Report has been prepared by the EPO or JPO .... $860.00 International preliminary examination fee paid to USPTO (37 C.F.R. 1.482) .. $700.00 No international preliminary examination fee paid to USPTO (37 C.F.R. 1.482) but international search fee paid to USPTO (37 C.F.R. 1.445(a)(2) .... $770.00 Neither international preliminary examination fee (37 C.F.R. 1.482) nor international search fee (37 C.F.R. 1.445(a)(2) paid to USPTO .... $1040.00 International preliminary examination fee paid to USPTO (37 C.F.R. 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) .... $ 96.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 860.00	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 C.F.R. 1.492(e)).	$	

Claims	Number Filed	Number Extra	Rate		
Total Claims	17 - 20 =		X $ 18.00	$ .00	
Independent Claims	2 - 3 =		X $ 80.00	$ .00	
Multiple Dependent Claims			$270.00 +	$	
TOTAL OF ABOVE CALCULATIONS =				$ 860.00	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 C.F.R. 1.9, 1.27, 1.28)				$	
SUBTOTAL =				$ 860.00	
Processing fee of $130.00 for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				$ 860.00	
Fee for recording the enclosed assignment (37 C.F.R. 1.21(h). The assignment must be accompanied by an appropriate cover sheet (37 C.F.R. 3.28, 3.31). $40.00 per property +					
TOTAL FEES ENCLOSED =				$ 860.00	
				Amount to be refunded	$
				charged	$

a. ☒ A check in the amount of $ 860.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. ________ in the amount of $ ______ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 501519. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 C.F.R. 1.494 or 1.495 has not been met, a petition to revive (37 C.F.R. 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

Schiff Hardin & Waite
Patent Department
6600 Sears Tower
Chicago, Illinois 60606

Steven H. Noll
SIGNATURE

Steven H. Noll
NAME

28,982
Registration Number

CERTIFICATE OF MAILING

"Express Mail" Mailing Label Number **EL 655299342 US**

Date of Deposit: November 29, 2000

I hereby certify that this correspondence is being deposited with the United States Postal "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to:

BOX PCT
Assistant Commissioner for Patents
Washington, D.C. 20231

Case Number: P00,1862

Jörg DAUERER et al.

METHOD AND RADIO STATION FOR SIGNAL TRANSMISSION IN A RADIO COMMUNICATION SYSTEM

Signature of person mailing documents and fee

09/701668

525 Rec'd PCT/PTO 29 NOV 2000

IN THE UNITED STATES ELECTED OFFICE
OF THE UNITED STATES PATENT AND TRADEMARK OFFICE
UNDER THE PATENT COOPERATION TREATY-CHAPTER II

"**REQUEST FOR APPROVAL OF DRAWING CHANGES**"

APPLICANT: Jörg DAUERER et al.

SERIAL NO.: EXAMINER:

FILING DATE: ART UNIT:

INTERNATIONAL APPLICATION NO.: PCT/DE99/01316

INTERNATIONAL FILING DATE: 3 May 1999

INVENTION: METHOD AND RADIO STATION FOR SIGNAL TRANSMISSION IN A RADIO COMMUNICATION SYSTEM

Hon. Assistant Commissioner for Patents
Box PCT
Washington D.C. 20231

SIR:

Applicants herewith request approval of the drawing changes in each of Figures 1, 2, 3, 4 and 5, as shown on the drawing copies marked in red attached hereto.

Respectfully submitted,

Steven H. Noll

Steven H. Noll (reg. no. 28,982)
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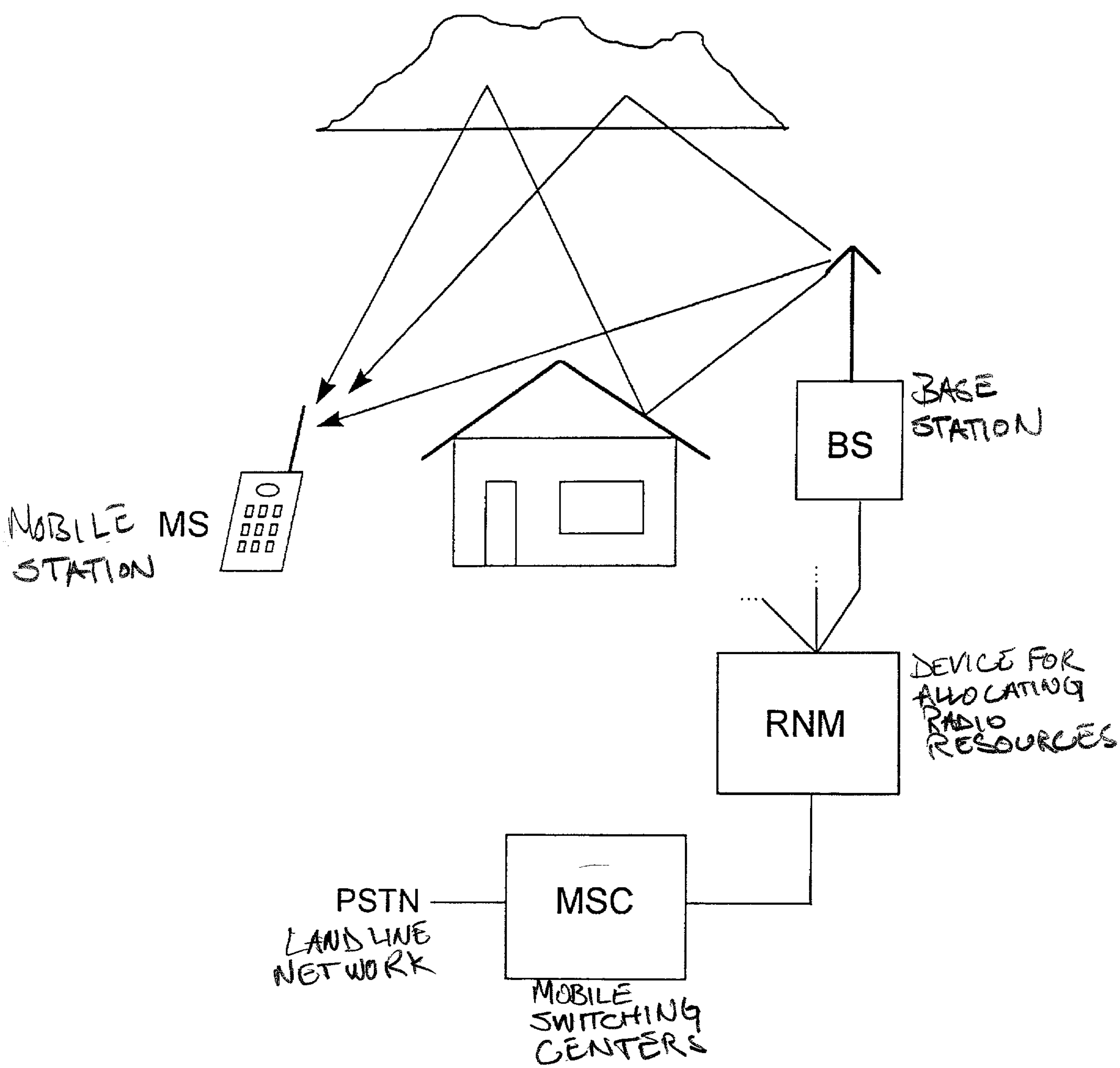
Telephone: 312-258-5785

ATTORNEY FOR APPLICANT

FIG 1


BS
BASE STATION
RNM
DEVICE FOR ALLOCATING RADIO RESOURCES
MOBILE STATION MS
PSTN
LAND LINE NETWORK
MSC
MOBILE SWITCHING CENTERS

09/701668

FIG 2

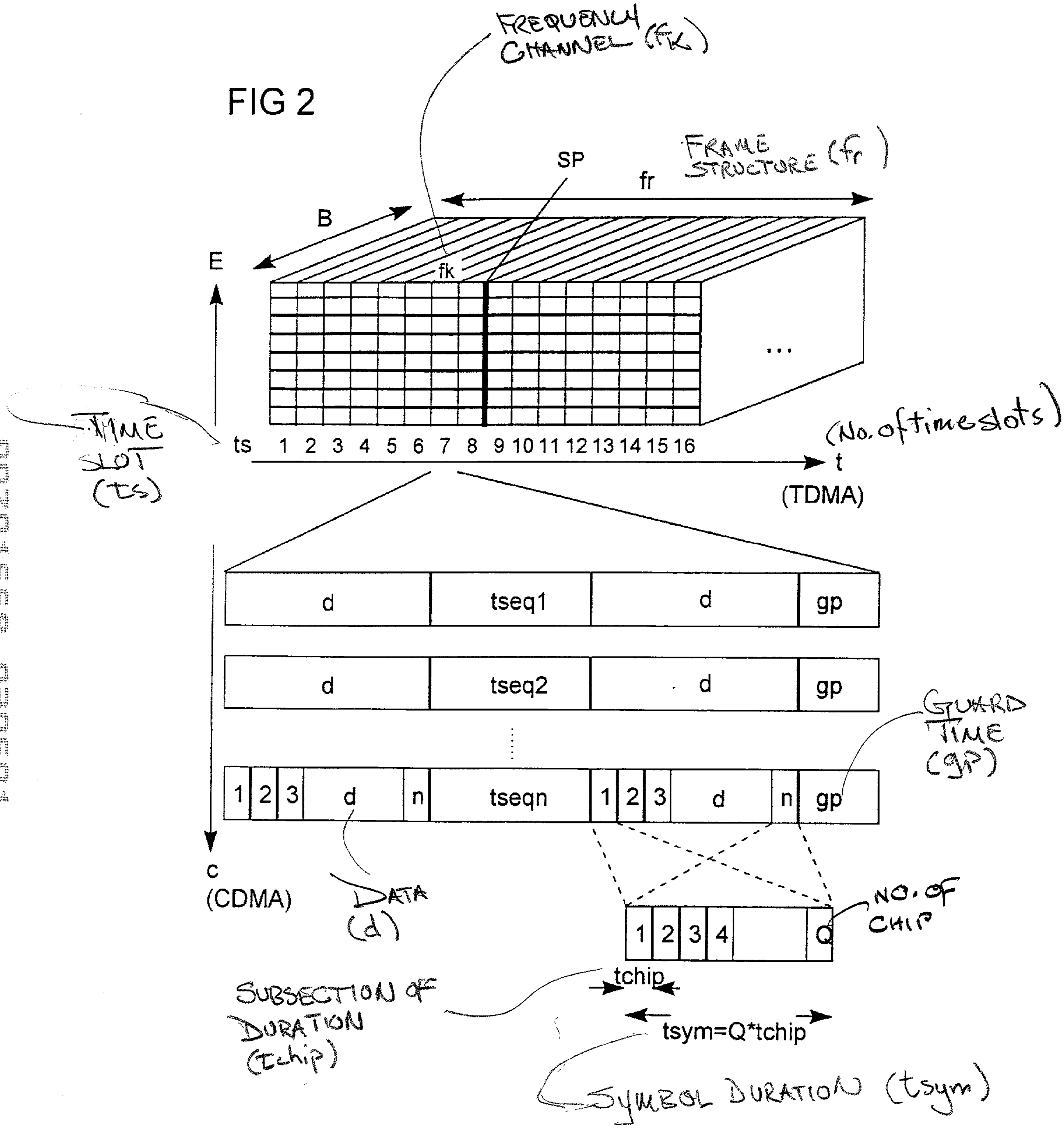


FIG 3

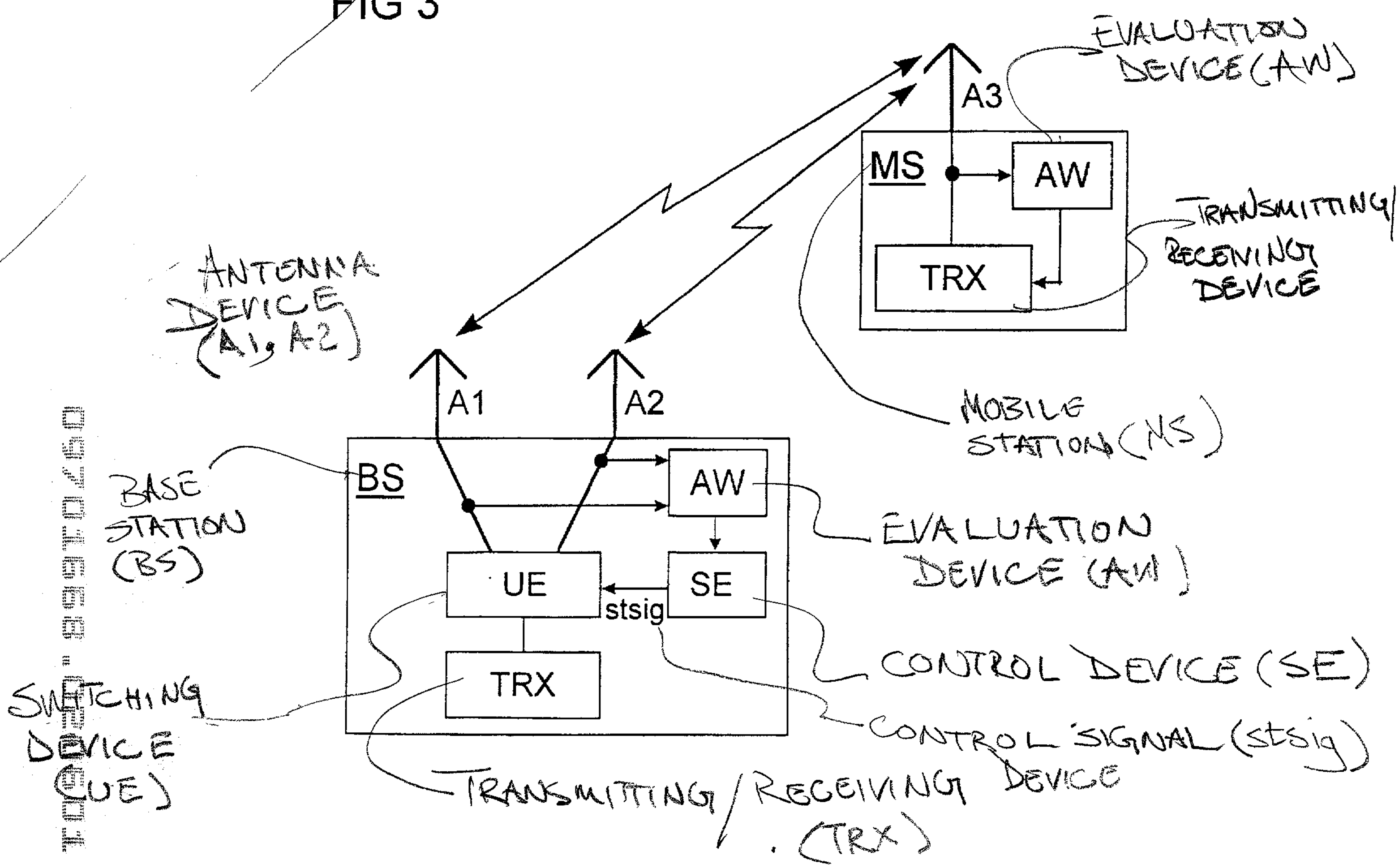
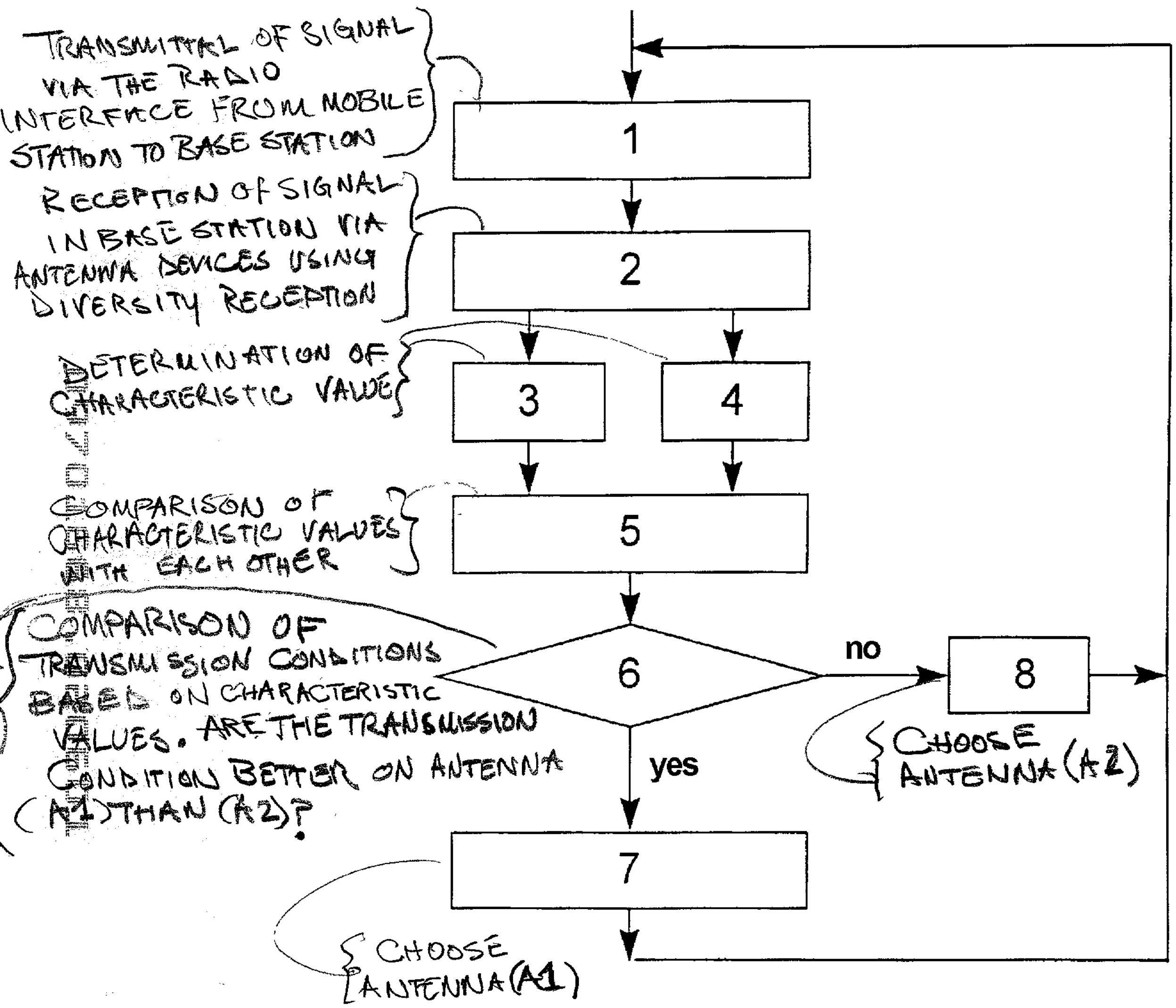
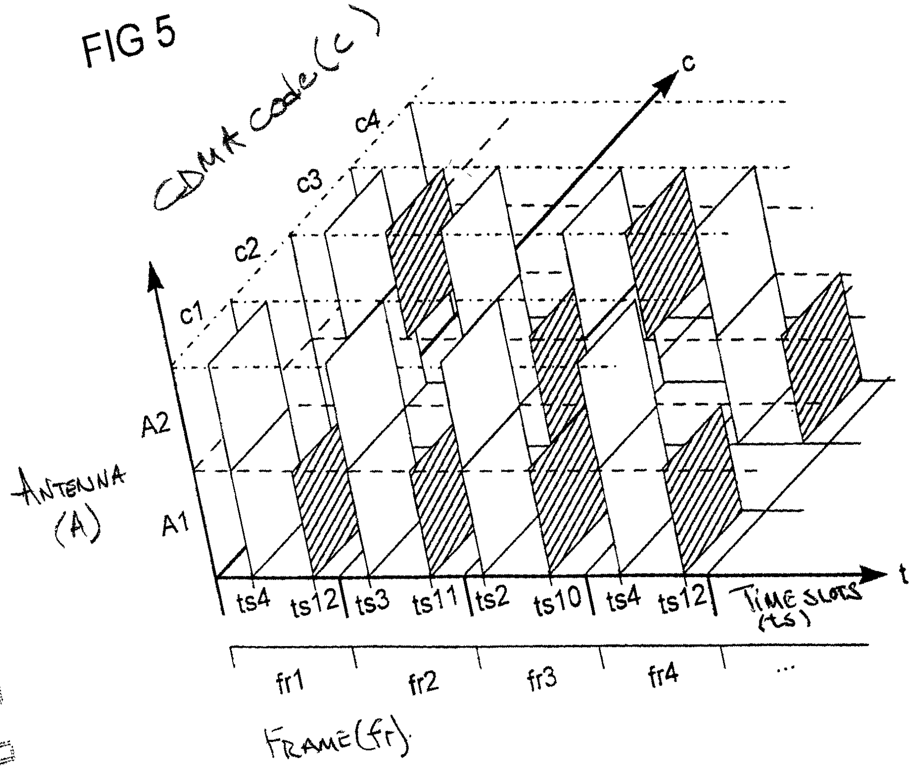

EVALUATION DEVICE (AW)
A3
MS
AW
TRX
TRANSMITTING/ RECEIVING DEVICE
ANTENNA DEVICE (A1, A2)
A1
A2
BASE STATION (BS)
BS
AW
EVALUATION DEVICE (AW)
UE
SE
stsig
MOBILE STATION (MS)
CONTROL DEVICE (SE)
TRX
SWITCHING DEVICE (UE)
CONTROL SIGNAL (stsig)
TRANSMITTING/RECEIVING DEVICE (TRX)

FIG 4


TRANSMITTAL OF SIGNAL VIA THE RADIO INTERFACE FROM MOBILE STATION TO BASE STATION
1
RECEPTION OF SIGNAL IN BASE STATION VIA ANTENNA DEVICES USING DIVERSITY RECEPTION
2
DETERMINATION OF CHARACTERISTIC VALUE
3
4
COMPARISON OF CHARACTERISTIC VALUES WITH EACH OTHER
5
COMPARISON OF TRANSMISSION CONDITIONS BASED ON CHARACTERISTIC VALUES. ARE THE TRANSMISSION CONDITION BETTER ON ANTENNA (A1) THAN (A2)?
6
no
8
CHOOSE ANTENNA (A2)
yes
7
CHOOSE ANTENNA (A1)

09/701668

FIG 5



IN THE UNITED STATES ELECTED OFFICE
OF THE UNITED STATES PATENT AND TRADEMARK OFFICE
UNDER THE PATENT COOPERATION TREATY-CHAPTER II

"**PRELIMINARY AMENDMENT**"

APPLICANT: Jörg DAUERER et al.

SERIAL NO.: EXAMINER:

FILING DATE: ART UNIT:

INTERNATIONAL APPLICATION NO.: PCT/DE99/01316

INTERNATIONAL FILING DATE: 3 May 1999

INVENTION: METHOD AND RADIO STATION FOR SIGNAL TRANSMISSION IN A RADIO COMMUNICATION SYSTEM

Hon. Assistant Commissioner for Patents
Box PCT
Washington D.C. 20231

SIR:

Amend the above-identified international application before entry into the national stage before the U.S. Patent & Trademark Office under 35 U.S.C. §371 as follows:

IN THE SPECIFICATION

At the top of each page, please delete "199801831".

On page 1, delete the first two lines;

before the title, insert --

SPECIFICATION

TITLE--;

after the title, insert --

BACKGROUND OF THE INVENTION

Field of the Invention--;

in line 8, change "particular in" to --particular to-- and after "radio" insert --communication--;

after line 9, insert --

Description of the Related Art--;

in line 10, before "information" insert --data--;

in line 11, delete "is or" and insert --type--;

in line 14, after "for example" insert --,--;

in line 15, delete "respectively,";

in line 16, change "system. The" to --system. As such, the-- and delete "in this case";

in line 17, change "which" to --that--;

in line 18, change "respective" to --selected--;

in line 23, after "CDMA" insert --(Code Division Multiple Access)--;

in line 28, change "produced" to --formed--;

in line 30, change "supplied via" to --advanced, (via--;

in line 31, change "etc." to --etc.)--;

in line 32, change "in the end," to --finally--;

in line 34, change "received" to --receiving--;

in line 38, change "widely differing" to --numerous--; and

in line 39, change "very different" to --various--.

On page 2, in line 2, after "refracted" insert --or absorbed--;

in line 3, change "buildings and the like" to --buildings, etc...;

in line 6, delete "a";

in line 7, change "effect" to --effects--;

in line 12, change "cancellation effects, which are also referred to as" to --cancellation or fading effects.--;

in line 13, change "fading effects. These" to --For example, these--;

in line 14, delete "that is to say" and insert --i.e.,--;

in line 21, delete "it is known from" to --according to--;

in line 22, change "system for" to --system,-- and delete "to" and insert --can--;

in line 34, change "systems, for which it is" to --systems. For these systems it is--;

in line 35, after "will" insert --be available--;

in line 36, delete "case be available for" and insert --of--; and

in line 38, delete "one frequency band".

On page 3, in line 17, before "mobile" insert --location of the--;

in line 18, change "location, and the base station then" to --. Subsequently, the base station--;

in line 19, change "predicted" to --selected--;

after line 20, insert --

SUMMARY OF THE INVENTION--;

in line 21, change "The invention is based on the object of" to --An object of the present invention is to--;

in line 22, change "specifying" to --specify-- and delete "which allow" and insert --that alleviates--;

in line 23, delete "future";

in line 24, delete "to be reduced" and delete "the" and insert --assigning at least one radio channel between a first radio station and transmitting at least one signal via a minimum of two transmission path. Subsequently, at least one characteristic value (such as, RXLE, RXQUAL, ta, C/I) that relates to the transmission condition on the radio interface is determined for each transmission path. By comparing a specific characteristic value among the transmission paths one transmission path is selected based on a control signal. If the difference between the specific characteristic value on the various transmission paths remains below a predetermined threshold value, the transmission path changes periodically such that a minimum of two successive decorrelated signals are transmitted via different transmission paths--;

delete lines 25-29;

in line 30, change "According" to --Accordingly,-- and delete "to the invention, in the method for--;

delete lines 31 and 32;

in line 33, delete "patent claim 1, which" and insert --the present invention--;

in line 34, delete "in which" to --such that--;

in line 35, after "defined" insert --by-- and delete "by"; and

in line 38, delete ",".

On page 4, in line 12, change "this" to --a--;

in line 17, change "the" to --this--;

in line 18, delete ",";

in line 19, delete "since" and insert --this is because--;

in line 20, delete "respectively, used" to --type of--;

in line 21, change "structure. In consequence, the special feature of this"

to --structure used. Accordingly, when--;

in line 22, delete "system, which is that";

in line 23, delete "is";

in line 24, delete "taken into account since";

in line 25, change "channel, as a result of" to --channel and thus--;

in line 26, delete "which";

delete line 28, and insert --In one embodiment of the present invention--;

in line 29, delete "invention,";

in line 32, before "determined" insert --subsequently-- and delete ",";

in line 33, delete ", from" and insert --based on--;

in line 35, before "actuates" insert --then--;

in line 38, delete "With this refinement" and insert --Accordingly--; and

in line 39, before "antenna" insert --better-- and delete "that is to".

On page 5, in line 1, change "say the transmission path, via which it is better to" to --i.e., the optimal transmission path to--;

delete line 3;

in line 4, after "conclusions" insert --may then--;

in line 5, change "station, and advantageously" to --station. This--;

in line 6, delete "to select" and insert --that selects--;

in line 7, delete "which offers" and insert --offering--;

delete line 9, and insert --Alternatively, in a second embodiment of the present--;

in line 10, delete "according to a second development of the present";

in lines 11 and 12, delete "in each case";

in line 12, change "Based on this feature, a" to --Accordingly, this--;

in line 14, after "by" insert --,--;

in line 15, after "case" insert --,--;

in line 17, before "determined" insert --then--;

in line 18, delete "respectively";

in line 25, after "station" insert --even--;

in line 26, delete ",";

in lines 29 and 30, delete "further alternative refinements" and insert --another embodiment--;

in line 33, delete ", or" and insert --alternatively,--;

in line 35, delete "this are"; and

in lines 38 and 39, delete "As a consequence of a further development," and insert --Furthermore,--.

On page 6, in line 2, delete "since, in consequence," and insert --as--;

in line 5, change "development" to --embodiment--;

in line 14, delete "inter alia";

in lines 21 and 22, delete "be operated" and insert --operate--;

in line 22, after "parallel" insert --,--;

in line 23, delete "As a consequence of a" and insert --A--;

in line 24, change "invention," to --invention for-- and delete "is" and insert --embodies--;

in line 25, delete "formed by";

in line 28, delete "respectively";

in lines 30 and 31, delete "high utilization of" and insert --efficiently utilizes the-- and delete "Based on this";

in line 32, delete "refinement, a" and insert --A--;

in line 35, delete "This" and insert --In particular, this--;

in line 36, delete "particularly";

in line 37, delete "In this" and insert --As such--; and

in line 38, delete "case".

On page 7, in line 2, delete "in" and insert --on-- and delete "The" and insert --This--;

in line 3, delete "refinement according to the invention";

in line 5, delete ",";

in line 6, delete "to be used";

in line 10, change "method, with" to --method. Here,--;

in line 11, change "being" (first occurrence) to --is-- and delete "being";

in line 12, delete "changed," and delete "respectively";

in line 13, delete "respectively" and after "band" insert --that is--;

in line 16, after "quality" insert --because the--;

in line 17, delete "since, in consequence,";

in line 20, delete ",";

in line 21, change "on reception, as a result of these changes" to --on the reception.--;

delete line 22;

in line 23, delete "development of the invention," and insert --In a further embodiment of the present invention--;

in line 26, delete "known inter alia from" and insert --again disclosed by--;

in line 27, delete "by" and insert --of-- and delete "already mentioned above--;

in line 28, change "since" to --because--; and

in line 32, after "the" insert --present--.

On page 8, in line 2, delete "since," and insert --because-- and delete

"present-day" and insert --current--;

delete lines 4-7;

after line 7, insert --

BRIEF DESCRIPTION OF THE DRAWINGS--;

in line 13, change "," to --.--;

in line 16, change "," to --.--;

in line 20, change "," to --.--;

in line 23, delete "as shown in" and insert --of-- and delete ", and" and insert --.--;

after line 27, insert --

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS--;

and

in line 28, insert the following –

The method and the radio station according to the present invention will now be explained in more detail with reference to the drawings.--.

On page 9, in line 2, change ", and" to --. Also,--;

in line 5, after "BS" insert --,--;

in line 10, before "mobile" insert --exemplary-- and delete ", which is";

in line 11, delete "mentioned by way of example, and" and insert --. These radio signals--;

in line 19, delete "which" and insert --that-- and delete "severely";

in line 29, delete "to" and insert --through--; and

in line 35, after "TDD" insert --(Time Division Duplex)--.

On page 10, in line 7, delete "A" and insert --Here, a--;

in line 8, delete "in this case"; and

in line 10, before "structured" insert --similarly-- and delete "in the same way".

On page 11, delete "Such" and insert --Examples of such--;

in line 4, delete ", which" and insert --that--;

in line 5, change "AW, are," to --AW are;--;

in line 6, delete "for example,";

in line 18, change "which" to --that--;

in line 20, delete "respectively";

in line 27, delete "," and insert --.--; and

in line 28, delete "that is to say" and insert --In other words,--.

On page 12, in line 7, after "reception" insert --also--;

in line 8, before "transmission" insert --selection of the--; delete "to be deduced"and delete "since" and insert --as--;

in line 14, change "A second example indicates a further option. In" to --Another alternative is illustrated by the following example.--;

in line 15, delete "this case, a" and insert --A--;

in line 19, before "receive" insert --simultaneously--;

in line 20, delete "at the same time";

in line 25, delete "which have been determined";

in line 26, change "for" to --(for--; and

in line 27, change "signaling" to --signaling)--.

On page 13, delete ", since" and insert --. This is because-- and delete "as";

in line 11, delete "a result of which the" and insert --resulting in different--

;

in line 12, change "differ, mean" to --, denote--;

in line 13, change "the situation" to --situations--;

in line 14, change "in" to --to--;

in line 16, change "for" to --(for--;

in line 17, delete "has already been" and insert --previously-- and delete "in the";

in line 18, delete "introduction to the description" and insert --)--;

in line 19, after "and" insert --the--;

in line 20, delete "which in each case have";

in line 22, change "conditions. During" to --capability. This means that during--;

in lines 24 and 25, delete "this refinement means that";

in line 30, delete ", as it were"; and

in line 31, delete "according to" and insert --of-- and before "invention" insert --present--.

On page 14, delete "according to" and insert --of-- and before "invention" insert --present--;

in line 7, after "BS" insert --,--;

in line 9, change "likewise" to --also--;

in line 12, delete "it is found";

in line 14, delete "that" and delete "respectively"; and

in line 39, delete "between".

On page 15, in line 12, change "5," to --5.--;

in line 13, delete "and this" and insert --This--; and

in line 31, after "Provided" insert --that--.

On page 16, in line 12, delete "has"; and

in line 13, delete "been" and delete "with reference" and insert --according--.

On page 17, in line 30, delete "is"; and

in line 36, delete "in accordance with a" and insert --according to a--.

On page 18, after line 2, add the following new paragraph --

Although other modifications and changes may be suggested by those skilled in the art, it is the intention of the inventors to embody within the patent warranted hereon all changes and modifications as reasonably and properly come within the scope of their contribution to the art.--.

IN THE DRAWINGS

Please amend Figures 1, 2, 3, 4 and 5 to add English text for clarification as shown on the drawing copies marked in red attached to the Request for Approval of Drawing Changes filed simultaneously herewith.

IN THE CLAIMS

On substitute page , line 1, change "Patent Claims" to --We Claim:--.

Please cancel claims 1-18 without prejudice.

Please substitute claims 19-35 as follows.

19. A method for signal transmission via a radio interface in a radio communications system, comprising the steps of:

utilizing a subscriber separation method to distinguish between signals;

defining a radio channel by at least one of a frequency band and a connection-specific fine structure;

assigning at least one radio channel for signal transmission between a first radio station and a second radio station;

transmitting at least one signal via at least two transmission paths;

determining for each transmission path at least one characteristic value, said characteristic value relating to transmission conditions on the radio interface;

comparing said respective ones of at least one characteristic value among the at least two transmission paths, said respective ones of said at least one characteristic value being a same type of characteristic value among said at least two transmission paths;

deriving a control signal based on said comparing step; and

selecting a transmission path based on said control signal, said transmission path being selected specifically for the radio channel for transmitting a subsequent signal, said transmission path being selected on a periodically changing basis provided that a difference for any characteristic value among said at least two transmission paths does not exceed a predetermined threshold, said any characteristic value being a same type of characteristic value among said at least two transmission paths, said periodically changing basis ensuring transmission of at least two successive decorrelated signals via different transmission paths.

20. A method according to claim 19, further comprising the steps of:

sending said at least one signal by the second radio station and receiving said at least one signal by at least two antenna devices of the first radio station said receiving performed by utilizing a diversity reception,

determining characteristic values from said at least one signal received by said at least two antenna devices; and

utilizing the control signal to actuate a switching device, said switching device switches a subsequent signal specifically for the radio channel to one of the at least two antenna devices of the first radio station.

21. A method according to claim 19, further comprising:

separating in time said at least one signal; and

transmitting said at least one signal via one transmission path in each case.

22. A method according to claim 21, further comprising:

sending said at least one signal that is separated in time, in each case, by one antenna device of the first radio station and receiving the said at least one signal that is separated in time by the second radio station;

determining characteristic values from a received signal; and

utilizing the control signal to actuate a switching device, said switching device switches a subsequent signal specifically for the radio channel to one of at least two antenna devices of the first radio station.

23. A method according to claim 22, further comprising the steps of:

transmitting said characteristic values to the first radio station; and

deriving the control signal from said characteristic values.

24. A method according to claim 22, further comprising the steps of:

deriving the control signal in the second radio station; and

transmitting the control signal to the first radio station.

25. A method according to claim 23, wherein the characteristic values and the control signal are transmitted by utilizing in-band signaling.

26. A method according to claim 19, wherein said connection-specific fine structure is formed by a CDMA code.

27. A method according to claim 26, further comprising the steps of:
utilizing a TD/CDMA method as the subscriber separation method; and
defining the radio channel by a frequency band and a time slot and a CDMA code.

28. A method according to claim 27, further comprising the step of:
transmitting signals by utilizing a TDD method, said signals being transmitted from the first radio station to the second radio station and from the second radio station to the first radio station, separated in time, in one frequency band.

29. A method according to claim 28, further comprising the step of:
transmitting at least two successive signals with a time slot being changed, said time slot being utilized for transmission, said time slot being changed periodically and in synchronism with a time protocol of the subscriber separation method.

30. A method according to claim 19, further comprising the step of:
transmitting at least two successive signals with a frequency band being changed, said frequency band being utilized for transmission, said frequency band being changed periodically and in synchronism with a time protocol of the subscriber separation method.

31. A method according to claim 19, further comprising the step of: utilizing a joint detection method for transmitting signals between the first radio station and the second radio station.

32. A method according to claim 19, wherein said at least one characteristic value is at least one of a bit error rate value and a value proportional to a signal delay time between the first radio station and the second radio station and a value for a signal-to-noise ratio.

33. A radio station for signal transmission via a radio interface in a radio communication system that utilizes a subscriber separation method to distinguish between signals, wherein a radio channel is defined by at least one of a frequency band and a connection-specific fine structure, said radio station comprising:

at least one antenna device for at least one of receiving and sending at least one signal, said at least one signal being transmitted via at least two transmission paths;

an evaluation device that determines at least one characteristic value, said characteristic value relating to transmission conditions on the radio interface for each of said at least two transmission paths;

a control device that derives a control signal based on a comparison of respective ones of said at least one characteristic value among the said at least two transmission paths, said at least one characteristic value being a same type of characteristic value among the said at least two transmission paths, said control signal also being derived based on a comparison between a threshold value and a difference for any characteristic value among the said at least two transmission paths; and

a switching device that is actuated by the control signal and selects a transmission path for transmittal of a subsequent signal of the radio station for the radio channel, said switching device selects a transmission path on a periodically changing basis provided that a difference for any characteristic value among said at least two transmission paths does not exceed a predetermined threshold, said any characteristic value being a same type of characteristic value among said at least two transmission paths, said periodically changing basis ensuring transmission of at least two successive decorrelated signals via different transmission paths.

34. A radio station according to claim 33, wherein said radio station is designed as a base station in a mobile radio system.

35. A radio station according to claim 33, wherein said radio station is designed as a mobile station in a mobile radio system.

IN THE ABSTRACT

In line 1, change "Abstract" to --Abstract of the Disclosure--;

delete lines 3 and 4;

in line 6, change "In the method" to --A method and apparatus--;

in line 7, change "system, at" to --system in which--;

in line 8, delete "least one" and insert --a--;

delete line 10, and insert --station. A signal is first transmitted via a minimum of--;

in line 11, delete "least" and delete "At least one" and insert --Subsequently, a--;

in line 14, before "transmission" insert --of the--, change "path" to --paths-

- and delete "derived";

delete lines 15-18, and insert --then derived based on a comparison of the characteristic value among the transmission paths. Subsequently, based on this control signal the optimal transmission path is selected for the upcoming signal transmissions.--; and

delete line 20.

REMARKS

The foregoing amendments to the specification and claims under Article 41 of the Patent Cooperation Treaty place the application into a form for prosecution before the U.S. Patent and Trademark Office under 35 U.S.C. §371. Accordingly, entry of these amendments before examination on the merits is hereby requested.

Respectfully submitted,

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ATTORNEY FOR APPLICANT

09/701668 PCT #4

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

RESPONSE TO NOTICE OF MISSING REQUIREMENTS AND PRELIMINARY AMENDMENT "A"

APPLICANT:	Jörg Dauerer et al.	Docket No. P00,1862	
SERIAL NO:	09/701,668	GROUP ART:	
DATE FILED:	November 29, 2000	EXAMINER:	
INVENTION:	"METHOD AND RADIO STATION FOR SIGNAL TRANSMISSION IN A RADIO COMMUNICATION SYSTEM"		

Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

In response to the Notification of Missing Requirements dated 5 January 2001 indicating a defective translation, Applicants hereby submit a new translation of the International Application in to English. A copy of the Notification and a check in the amount of the fee is also enclosed.

Applicants assert that the Notification of Missing Requirements requesting an oath/declaration, (Part 2 box C), is in error, and correction is required.

Applicant also encloses a substitute Specification and a separate marked up copy to show all changes relative to the new English translation, according to 37CFR 1.125 (b). Accordingly, please replace the specification in the file with the enclosed Substitute specification. The substitute Specification includes no new matter.

Please disregard the previously submitted Preliminary Amendment mailed on November 29, 2000.

IN THE CLAIMS

On substitute page , line 1, change "Patent Claims" to --We Claim:--.

Please cancel claims 1-19 without prejudice.

Please add new claims 20-36 as follows:

20. A method for signal transmission via a radio interface in a radio communications system, comprising the steps of:
utilizing a subscriber separation method to distinguish between signals;
defining a radio channel by at least one of a frequency band and a connection-specific fine structure;
assigning at least one radio channel for signal transmission between a first radio station and a second radio station;
transmitting at least one signal via at least two transmission paths;
determining for each transmission path at least one characteristic value, said characteristic value relating to transmission conditions on the radio interface;
comparing said respective ones of at least one characteristic value among the at least two transmission paths, said respective ones of said at least one characteristic value being a same type of characteristic value among said at least two transmission paths;
deriving a control signal based on said comparing step; and
selecting a transmission path based on said control signal, said transmission path being selected specifically for the radio channel for transmitting a subsequent signal, said transmission path being selected on a periodically changing basis provided that a difference for any characteristic value among said at least two transmission paths does not exceed a predetermined threshold, said any characteristic value being a same type of characteristic value among said at least two transmission paths, said periodically changing basis ensuring transmission of at least two successive decorrelated signals via different transmission paths.

21. A method according to claim 20, further comprising the steps of:
sending said at least one signal by the second radio station and receiving said at least one signal by at least two antenna devices of the first radio station said receiving performed by utilizing a diversity reception,
determining characteristic values from said at least one signal received by said at least two antenna devices; and
utilizing the control signal to actuate a switching device, said switching device switches a subsequent signal specifically for the radio channel to one of the at least two antenna devices of the first radio station.

22. A method according to claim 20, further comprising:
separating in time said at least one signal; and
transmitting said at least one signal via one transmission path in each case.

23. A method according to claim 22, further comprising:
sending said at least one signal that is separated in time, in each case, by one antenna device of the first radio station and receiving the said at least one signal that is separated in time by the second radio station;
determining characteristic values from a received signal; and
utilizing the control signal to actuate a switching device, said switching device switches a subsequent signal specifically for the radio channel to one of at least two antenna devices of the first radio station.

24. A method according to claim 23, further comprising the steps of:
transmitting said characteristic values to the first radio station; and
deriving the control signal from said characteristic values.

25. A method according to claim 23, further comprising the steps of:
deriving the control signal in the second radio station; and
transmitting the control signal to the first radio station.

26. A method according to claim 24, wherein the characteristic values and the control signal are transmitted by utilizing in-band signaling.

27. A method according to claim 20, wherein said connection-specific fine structure is formed by a CDMA code.

28. A method according to claim 27, further comprising the steps of: utilizing a TD/CDMA method as the subscriber separation method; and defining the radio channel by a frequency band and a time slot and a CDMA code.

29. A method according to claim 28, further comprising the step of: transmitting signals by utilizing a TDD method, said signals being transmitted from the first radio station to the second radio station and from the second radio station to the first radio station, separated in time, in one frequency band.

30. A method according to claim 29, further comprising the step of: transmitting at least two successive signals with a time slot being changed, said time slot being utilized for transmission, said time slot being changed periodically and in synchronism with a time protocol of the subscriber separation method.

31. A method according to claim 20, further comprising the step of: transmitting at least two successive signals with a frequency band being changed, said frequency band being utilized for transmission, said frequency band being changed periodically and in synchronism with a time protocol of the subscriber separation method.

32. A method according to claim 20, further comprising the step of: utilizing a joint detection method for transmitting signals between the first radio station and the second radio station.

33. A method according to claim 20, wherein said at least one characteristic value is at least one of a bit error rate value and a value proportional to a signal delay time between the first radio station and the second radio station and a value for a signal-to-noise ratio.

34. A radio station for signal transmission via a radio interface in a radio communication system that utilizes a subscriber separation method to distinguish between signals, wherein a radio channel is defined by at least one of a frequency band and a connection-specific fine structure, said radio station comprising:

at least one antenna device for at least one of receiving and sending at least one signal, said at least one signal being transmitted via at least two transmission paths;

an evaluation device that determines at least one characteristic value, said characteristic value relating to transmission conditions on the radio interface for each of said at least two transmission paths;

a control device that derives a control signal based on a comparison of respective ones of said at least one characteristic value among the said at least two transmission paths, said at least one characteristic value being a same type of characteristic value among the said at least two transmission paths, said control signal also being derived based on a comparison between a threshold value and a difference for any characteristic value among the said at least two transmission paths; and

a switching device that is actuated by the control signal and selects a transmission path for transmittal of a subsequent signal of the radio station for the radio channel, said switching device selects a

transmission path on a periodically changing basis provided that a difference for any characteristic value among said at least two transmission paths does not exceed a predetermined threshold, said any characteristic value being a same type of characteristic value among said at least two transmission paths, said periodically changing basis ensuring transmission of at least two successive decorrelated signals via different transmission paths.

35. A radio station according to claim 34, wherein said radio station is designed as a base station in a mobile radio system.

36. A radio station according to claim 34, wherein said radio station is designed as a mobile station in a mobile radio system.

REMARKS

Please disregard the previously submitted Preliminary Amendment mailed on November 29, 2000 because of an inadvertent error in the translation that caused inaccurate numbering of the claims.

Applicants assert that the Notification of Missing Requirements requesting an oath/declaration, (Part 2 box C), is in error. Specifically, the Applicants filed the Declaration of the inventors on November 29, 2000. The Declaration identifies the German language PCT application as attached. The translation error does not effect the validity of the executed Declaration. The receipt of the Declaration is acknowledged by the PTO as indicated by marking under Part 1 of the Notification of Missing Requirements. Likewise, the returned post card receipt, a copy of which is enclosed, shows that the "executed Declr." was received by the Patent and Trademark Office on November 29, 2000. Accordingly, Applicants submit that the Declaration has already been filed.

The foregoing amendments to the claims under Article 41 of the Patent Cooperation Treaty place the application into a form for prosecution before the U.S. Patent and Trademark Office under 35 U.S.C. §371. Accordingly, entry of these amendments before examination on the merits is hereby requested.

Respectfully submitted,

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I hereby certify that this correspondence is being deposited with the United States Postal Service as First Class Mail in an envelope addressed to:

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Washington, D.C. 20231

on February 2, 2000.

Melvin A. Robinson

Substitute Specification

Rec'd PCT/PTO 06 FEB 2001
09/701668 #4

SPECIFICATION

TITLE

METHOD AND RADIO STATION FOR SIGNAL TRANSMISSION IN A RADIO COMMUNICATIONS SYSTEM

BACKGROUND OF THE INVENTION

Field of the Invention

The invention relates to a method and a radio station for signal transmission in a radio communications system, in particular to a mobile radio communication system.

Description of the Prior Art

In radio communications systems, data information such as voice, video information or other data type are transmitted by means of electromagnetic waves via a radio interface between a transmitting and a receiving radio station, for example, a base station and a mobile station, in the case of a mobile radio system. As such, the electromagnetic waves are transmitted at carrier frequencies that are in the frequency band intended for the selected system. The carrier frequencies for the GSM mobile radio system (<u>G</u>lobal <u>S</u>ystem for <u>M</u>obile Communication) are in the 900 MHz, 1 800 MHz and 1 900 MHz bands. Carrier frequencies in the band around 2 000 MHz are intended to be used for future mobile radio systems using CDMA (Code Division Multiple Access) and TD/CDMA transmission methods via the radio interface, such as the UMTS (Universal Mobile Telecommunication System) or other 3rd generation systems.

The signals to be transmitted are formed in a transmitting devices in the radio station. The transmission signals are advanced, (via cable links and various other devices such as preamplifiers etc.) to an antenna device which, finally transmits the

radio signals. The transmitted radio signals are received and evaluated by a receiving devices in the receiving radio station.

In real operational conditions for radio communications systems, the radio signals are subject to numerous types of interference and reach the receiving device on various propagation paths. Apart from a direct propagation path, the radio signals can also be reflected or refracted or absorbed on obstructions such as mountains, trees, buildings, etc... The radio signals from the various propagation paths are superimposed in the receiving device. This leads to cancellation effects which at times have severe adverse effects on reception of the radio signals, in this context refer to J.D. Parsons, "The Mobile Radio Propagation Channel", Pentech Press Publishers, London, 1992, pages 108-113.

Various methods are known for overcoming these cancellation or fading effects. For example, these fading effects can be reduced by antenna diversity, i.e., by using a number of antennas for the transmitting and/or receiving device. However, since the use of antenna diversity means an increase in the costs and complexity in the base station and in the mobile station of a mobile radio system, antenna diversity has so far been used only in the base stations.

Furthermore, according to the GSM mobile radio system, the reception conditions can be improved by using a frequency hopping method (FH), that is to say changing the transmission frequency for the radio signals (M. Mouly, M.B. Pautet, "The GSM System for Mobile Communications", 1992, inter alia, pages 218-223). Furthermore, methods and devices are known from the prior art according to the documents DE 44 32 928, WO 93/20625 and WO 95/32558 which use a combination of a frequency hopping method and an antenna diversity method. Apart from complex

implementation, these methods have the disadvantage that they cannot be used for the broadband 3rd generation mobile radio systems. For these systems it is predicted that only one frequency band will be available in each of the uplink and downlink direction for the FDD method (FDD - Frequency Division Duplex), and for the uplink and downlink direction for the TDD method (TDD - Time Division Duplex).

A mobile radio system based on microcells is known from the article by Kondo, Suwa "Linear Predictive Transmission Diversity for TDMA/TDD Personal Communication Systems", IEICE Trans. Commun., Vol. E79-B, No. 10, October 1996, pages 1586-1591, in which the base station makes a linear prediction of the signal strength at the mobile station on the basis of the reciprocity between the uplink and the downlink direction. The base station receives a signal in the uplink direction from the mobile station using reception diversity by means of two antenna devices, and measures the signal strength of the received signal during the reception time. The base station uses these measurements to determine which antenna produces the greatest signal strength at the location of the mobile station. Subsequently, the base station transmits the signal in the downlink direction via the selected antenna.

SUMMARY OF THE INVENTION

An object of the present invention is to specify a method and a radio station that alleviates the cancellation effect in radio communications systems. This object is achieved by assigning at least one radio channel between a first radio station and transmitting at least one signal via a minimum of two transmission path. Subsequently, at least one characteristic value (such as, RXLE, RXQUAL, ta, C/I) that relates to the transmission condition on the radio interface is determined for each transmission path.

By comparing a specific characteristic value among the transmission paths one transmission path is selected based on a control signal. If the difference between the specific characteristic value on the various transmission paths remains below a predetermined threshold value, the transmission path changes periodically such that a minimum of two successive decorrelated signals are transmitted via different transmission paths.

Accordingly, the present invention uses a subscriber separation method to distinguish between signals, such that a radio channel is defined by at least a frequency band and a connection-specific fine structure, at least one radio channel is assigned for signal transmission between a first and a second radio station and at least one signal is transmitted via at least two transmission paths. At least one characteristic value relating to the transmission conditions on the radio interface is determined for each transmission path. A control signal is derived from a comparison of the mutually corresponding characteristic values, by means of which control signal the transmission path is selected specifically for the radio channel for transmitting a subsequent signal.

This method advantageously offers the capability to determine a characteristic value for each transmission path, in order to carry out an assessment of the transmission conditions for a transmission path. The comparison of the respective characteristic values determined for each transmission path is used to select the most suitable path, and one or more subsequent signals are transmitted on this path. The determination of this characteristic values is carried out separately and specifically for each radio channel this is because the transmission conditions may differ depending on the type of connection-specific fine structure used. Accordingly, when a number of radio channels within one frequency band are used for signal transmission, the optimum

transmission path is determined for each radio channel and thus the transmission characteristics are advantageously optimized.

In one embodiment of the present invention the signal is sent by the second radio station and is received via at least two antenna devices of the first radio station using diversity reception. The characteristic values are subsequently determined and the control signal derived based on the signal received by the respective antenna device. The control signal then actuates a switching device which switches a subsequent signal specifically for the radio channel to one of the antenna devices of the first radio station. Accordingly, it is possible to determine in the first radio station the better antenna device, i.e., the optimal transmission path to receive the signal sent by the second radio station. Conclusions may then to be drawn on the transmission situation for the first radio station. This makes it possible to use the switching device that selects the antenna device offering the better transmission quality.

Alternatively, in a second embodiment of the present invention, the signal is transmitted, separated in time, via one transmission path. Accordingly, this further refinement of the invention means that the signal which is separated in time is sent by, in each case, one antenna device of the first radio station, and is received by the second radio station. The characteristic values are then determined from the received signal, and the control signal is derived from their comparison. The control signal is used to actuate a switching device, which switches a subsequent signal specifically for the radio channel to one of the antenna devices of the first radio station. This refinement advantageously allows the transmission conditions on the radio interface to be determined in the second radio station even if the latter has only one antenna device

and allows the subsequent signals to be switched to one of the antenna devices of the first radio station.

In this case, according to another embodiment, the characteristic values determined in the second radio station can be transmitted to the first radio station, which derives the control signal from them and actuates the switching device alternatively, the control signal is derived in the second radio station from the specific characteristic values and transmitted to the first radio station, with the control signal actuating the switching device in the first radio station. Furthermore, the characteristic values and the control signal can advantageously be transmitted using in-band signaling as there is no disadvantageous effect on the transmission capacity of the respective radio channel.

According to a further embodiment of the invention, when a number of radio channels are assigned for signal transmission between the first radio station and the second radio station, the control signal is derived from a comparison of all the mutually corresponding characteristic values intended for the respective radio channels. The control signal is used to select a common transmission path for all the radio channels for the subsequent signals. This method, which is referred to as channel pooling, is known from the article by J. Mayer, J. Schlee, T. Weber "Protocol and Signalling Aspects of Joint Detection CDMA", PIMRC'97, Helsinki, 1997, pages 867-871. The channel pooling method is used advantageously, for example, in order to allow communications links to be provided with different data rates to and from radio stations, or to allow a number of services to operate in parallel, on one communications link.

A further refinement of the invention for the connection-specific fine structure embodies a CDMA code. The subscriber separation methods chosen for the third

generation mobile radio system UMTS, according to which a distinction is drawn between subscribers on the basis of the CDMA code, advantageously allows a large number of radio channels in one broadband frequency band, and thus efficiently utilizes the scarce radio resources. A further refinement uses a TD/CDMA method as the subscriber separation method. In this case, a radio channel is defined by a frequency band, a timeslot and a CDMA code. In particular, this subscriber separation method can be used advantageously if the signals are transmitted using a TDD method. As such, the signals are transmitted from the first radio station to the second radio station, and from the second radio station to the first radio station, separated in time, on one frequency band. This allows the most suitable transmission path to be determined specifically for each radio channel in a timeslot and for transmitting subsequent signals.

In addition to the selection of a transmission path, further refinements of the invention allow at least two successive signals to be transmitted, using a TD/CDMA subscriber separation method. Here, the timeslot is changed and/or with the frequency band and with the used timeslot or the used frequency band that is being changed periodically and in synchronism with the time protocol of the subscriber separation method. These refinements have the advantage of increased transmission quality because the interference which occurs in specific timeslots or in a specific frequency band interferes with only a small proportion of the transmitted signals and thus has only a minor effect on the reception.

In a further embodiment of the present invention the transmitted signals are received in the first radio station and/or in the second radio station using a joint detection method. This method, which is again disclosed by the article of J. Mayer et. al., allows the reception quality to be increased advantageously because all the fine

structures in use are used for detection of a signal which is coded by means of a connection-specific fine structure.

According to a further refinement of the present invention, the characteristic value can be related to a reception level, a bit error rate and/or a value proportional to the signal delay time between the first radio station and the second radio station, and/or to a signal-to-noise ratio. Characteristic values which can be found particularly easily in radio communications systems are the reception level and the bit error rate (which are quoted as scaled values RXLEV, RXQUAL) because as a rule, they already exist in current implementations.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a block diagram of a radio communications system, in particular of a mobile radio system, and a radio communications system-typical operational environment which is characterized by multipath propagation.

Figure 2 shows a schematic illustration of the frame structure of the radio interface, and of the construction of a radio block.

Figure 3 shows a block diagram of the radio station according to the invention as a base station and a mobile station in a mobile radio system.

Figure 4 shows a flowchart of the method according to the invention for the radio communications system of Figure 1.

Figure 5 shows an illustration with respect to time of an example of signal transmission from the point of view of a base station in a mobile radio system.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The method and the radio station according to the present invention will now be explained in more detail with reference to the drawings.

The radio communications system illustrated in Figure 1 and in the form of a mobile radio system comprises a large number of mobile switching centers MSC, which are networked to one another and produce access to a landline network PSTN. Furthermore, these mobile switching centers MSC are each connected to at least one device RNM for allocating radio resources. Each of these devices RNM in turn allows a connection to be set up to at least one base station BS. Such a base station BS is a radio station which can set up links via a radio interface to other radio stations, for example to mobile stations MS or to stationary terminals. At least one radio cell is formed by each base station BS. Also, radio stations located in the area of this radio cell are supplied with radio resources. In addition, a number of radio cells can be supplied by each base station BS, if sectorization is used or if the cell structures are hierarchical.

In real operational conditions for radio communications systems, radio signals are subject to widely differing types of interference between the base station BS and the exemplary mobile station MS. These radio signals reach the receiving device in the mobile station MS on very different propagation paths. Apart from a direct propagation path, the radio signals can also be reflected or defracted on obstructions such as mountains, trees, buildings or the like. The radio signals from the various propagation paths are superimposed in the receiving device, which leads to cancellation effects that

can adversely affect reception of the radio signals. The functionality of the illustrated structure is used by the radio communications system according to the invention.

The frame structure of the radio interface, as it is implemented in the third generation mobile radio system UMTS, is shown in Figure 2. A broadband frequency band, for example with a bandwidth of B = 5 MHz, is split in accordance with a TDMA component into a number of timeslots ts, for example 16 timeslots ts1 through ts16. Each timeslot ts within the frequency band B forms a frequency channel fk. The successive timeslots ts within the frequency band B are broken down in accordance with a frame structure. Thus, for example, 16 timeslots ts1 to ts16 are combined to form a frame fr.

When using a TDD (Time Division Duplex) transmission method, some of the timeslots ts1 to ts16 are used for signal transmission in the uplink direction, and some of the timeslots ts1 to ts16 are used for transmission in the downlink direction, with the transmission in the uplink direction taking place, for example, at a time before the transmission in the downlink direction. In-between, there is a switching point SP, by means of which it is possible to vary the number of timeslots which are used for transmission in the uplink direction and the number of timeslots for the downlink direction in a flexible manner. Here, a frequency channel fk for the uplink direction corresponds to the frequency channel fk for the downlink direction. The other frequency channels fk are similarly structured.

Within the frequency channels fk which are intended for user data transmission, information from a number of communications links is transmitted in radio blocks. These radio blocks for user data transmission are composed of sections with data d, each of which has sections embedded in it containing training sequences tseq1 to tseqn

which are known at the reception end. The data d are spread on a connection-specific basis using a fine structure, a spread code c (CDMA code), so that, for example, n links can be separated by this CDMA component at the reception end.

The spreading of individual symbols of data d with Q chips means that subsections of duration tchip are transmitted within the symbol duration tsym. The Q chips in this case form the individual CDMA code c. A guard time gp is also provided within the timeslot ts, to compensate for different signal delay times on the links for successive timeslots ts.

By way of example, Figure 3 shows two radio stations, which are in the form of a base station BS and a mobile station MS in a mobile radio system. There is a radio link for signal transmission between the two radio stations BS and MS. The base station BS is equipped with two antenna devices A1 and A2 and a transmitting/receiving device TRX, via which it can transmit and receive user and signaling information. An evaluation device AW, which is also provided in the base station BS, is supplied with signals output from the respective reception path of the two antenna devices A1 and A2, and characteristic values relating to the transmission conditions of the radio interface are in each case determined from them. Example of such characteristic values that may be obtained only after internal conversions in the evaluation device AW are; the reception lever RXLEV, a scaled variable relating to the bit error rate RXQUAL, a lead time ta or a signal-to-noise ratio C/I. The characteristic values RXLEV, RXQUAL can be signaled, for example, by the mobile station MS as in the GSM mobile radio system, while the details relating to the signal delay time can be obtained in the form of the lead time ta, and the details relating to the signal-to-noise ratio C/I

can be obtained from the received signals in the base station BS itself.

The characteristic values determined for the respective reception path are supplied to a control device SE that is connected downstream of the evaluation device AW and carries out a comparison of mutually corresponding characteristic values. The control device SE uses this comparison to derive a control signal stsig and thus actuates a switching device UE which switches signals to be sent in radio channels downstream of the transmitting/receiving device TRX to one of the antenna devices A1 or A2. In this case, the signals can be switched independently for transmission and reception. In other words, the signals sent by the mobile station MS are, for example, received via both antenna devices A1 and A2 and are supplied to the transmitting/receiving device TRX. This is used advantageously according to the invention if the reception of the radio channels in the base station BS takes place using a joint detection method.

Various scenarios are feasible for determining the characteristic values and for deriving the control signal stsig. According to a first example, this can be done by the mobile station MS sending a signal in an assigned radio channel, with this signal being received by the two antenna devices A1 and A2 using a diversity principle. The evaluation device AW uses this received signal to determine the respective characteristic values for the subsequent determination of which transmission path and which antenna device A1 or A2 offers the better transmission conditions. This determination process related to reception also allows the selection of the transmission situation, as the transmission conditions are generally identical for transmission and reception. The control device SE in the base station BS selects that antenna device A1

or A2 via which signals are then sent in the downlink direction in the same radio channel.

Another alternative is illustrated by the following example. A signal is in each case transmitted in a radio channel to the mobile station MS, separated in time, by the base station BS. Time separation is required since the mobile station MS has only one antenna device A3 and is thus unable to simultaneously receive two signals in the same radio channel. The mobile station MS is in this case equipped with an evaluation device AW in which it can determine characteristic values relating to the transmission conditions on the respective transmission path. These characteristic values are then sent by the mobile station MS, (for example via in-band signaling), to the base station BS, in which the values are supplied to the control device SE which uses them to derive the control signal stsig for actuating the switching device UE.

According to a third example, the mobile station MS may also be equipped with a control device SE, using which it derives a control signal stsig directly from the characteristic values determined in the evaluation device AW, and transmits this control signal stsig to the base station BS, with the switching device UE being actuated by this control signal stsig.

Furthermore, it is feasible for characteristic values relating to the transmission conditions for the radio channel to be determined both in the base station BS and in the mobile station MS, and for these values to be supplied to the control device SE in the base station BS, which means that it is possible to make a more accurate estimate

of the actual transmission conditions on the radio interface.

The characteristic values should be determined separately for each radio channel in a timeslot in a radio communications system having TD/CDMA subscriber separation. This is because the different CDMA spread codes c, resulting in different radio channels in a timeslot ts, denote that different transmission conditions may also occur. In situations where a number of radio channels are assigned to one timeslot ts for signal transmission between the base station BS and the mobile station MS, (for example using the channel pooling principle as previously explained), characteristic values are determined separately for each radio channel and the signals to be sent from the base station BS are sent via the antenna device A1 or A2 which has the better transmission capability. This means that during the process of assigning radio channels in a timeslot ts to a number of mobile stations MS, the best transmission path is selected for each radio channel. Depending on the selected antenna device A1, A2 via which subsequent signals will be sent in the respective radio channel, the transmission power for each timeslot ts and CDMA code c can be controlled separately.

The method of the present invention can also be applied, for example, in the same way to CDMA subscriber separation methods, in which a radio channel is in each case defined by the frequency band B and a CDMA code c. In this case, characteristic values are in each case determined and a transmission path for the radio channel is selected, for example, at periodic time intervals.

The method of the present invention can be simplified in that, for example, a number of radio channels which have been assigned to a single communications link between the base station BS, and a mobile station MS on the channel pooling principle are each sent via only one antenna device A1 or A2 of the base station BS if the differences in the transmission conditions on the basis of the different CDMA code c are not significant. This also simplifies the process of controlling the transmission power for transmission to the individual mobile stations MS.

If during the process of determining the characteristic values for the reception paths the difference between the determined characteristic values for the two reception paths of the antenna device A1, A2 is not greater than a predetermined threshold value, that is to say the transmission conditions for both paths are, for example, virtually identical, protected signal transmission can be achieved by periodically changing between the antenna device A1, A2 when the base station BS is transmitting. This results in successive, decorrelated signals at the mobile station MS location, thus advantageously improving the transmission quality when interference is present on the radio interface.

For additional decorrelation of successive signals, it is also possible, for example, to change the timeslot ts while maintaining the assigned CDMA code c if transmission problems occur repeatedly in specific timeslots ts. A further option, in the situation where a number of frequency bands B are available to the radio communications system, is to change between the frequency bands B using a type of frequency hopping method.

Figure 4 shows an example of a flowchart for one refinement of the method according to the invention. By way of example, in the flowchart block identified by the number 1, a signal is sent via the radio interface from the mobile station MS to the base station BS. The transmitted signal is transmitted, for example, in an assigned radio channel. The block identified by 2 represents reception of the transmitted signal in the base station BS via two antenna devices A1 and A2 using diversity reception. According to the blocks 3 and 4, the signal received via the respective antenna device A1 and A2 is used to determine characteristic values relating to the transmission conditions on the radio interface for the respective transmission paths. The characteristic values which are determined and correspond to one another are compared with one another in the block 5. This can be done, for example, in an evaluation device AW in the base station BS. The decision resulting in the selection of the better transmission conditions is made in the decision block 6 depending on the type of characteristic values. If the transmission conditions for the transmission path via the first antenna device A1 are better than the transmission conditions via the second antenna device A2, then, in the block 7, the signals to be sent subsequently are switched in the radio channel via the first antenna device A1 to the mobile station MS. If, on the other hand, the transmission conditions via the second antenna device A2 are better, then, as shown in block 8, signals to be sent subsequently by the base station BS are sent via the second antenna device A2.

In addition to the procedure shown in Figure 4, the sequence can be supplemented, for example, by checking the difference between the specific characteristic values of the reception paths. Provided that this difference is not greater than a predetermined threshold value, then signals to be sent subsequently are

alternately switched to in each case one antenna device A1 or A2 using an antenna hopping method, thus advantageously decorrelating the transmitted signals. The evaluation of the signals sent by the mobile station MS can in this case be controlled by a timer, which is matched to the subscriber separation method and/or is synchronized with it.

Figure 5 shows a three-dimensional diagram in which, by way of example, signal transmission according to the invention is carried out in a radio communications system having TD/CDMA subscriber separation and in which the uplink and downlink directions are separated using a TDD method. Firstly, the time t is plotted in the horizontal plane and is split into frames fr1 to fr4 using the TDMA subscriber separation method. Each frame fr1 to fr4 is subdivided into, for example, 16 timeslots ts1 to ts16. As already explained according to Figure 2, the uplink and downlink directions are separated by a switching point SP, so that transmission takes place in both the uplink direction and the downlink direction within one frame fr. Furthermore, a distinction on the basis of the CDMA code c is made in the horizontal plane. By way of example, four possible CDMA codes c1 to c4 are shown, which allow separation into four radio channels within one timeslot ts when using a frequency band b. In the vertical direction, two antenna devices A1 and A2 are shown, by way of example, via which the signals can be sent from the base station BS.

The example shown in Figure 5 is based on two radio channels being assigned to a communications link between a base station BS, which has two antenna devices A1 and A2, and a mobile station MS, using the channel pooling

principle. The diagram in this case shows the processes of reception and transmission from the point of view of the base station BS. This configuration, which is illustrated by way of example, corresponds to Figure 3. In the initial situation, the allocated radio channels are defined in the first frame fr1 by the timeslot ts4 for the uplink direction and by the timeslot ts12 for the downlink direction, and by the CDMA codes c1 and c3 as well. Accordingly, in the first frame fr1, the mobile station MS sends signals in the uplink direction in the timeslot ts4, using the CDMA codes c1 and c3, to the base station BS. The transmitted signals are received via the antenna devices A1 and A2 in the base station BS, and characteristic values relating to the respective transmission conditions on the radio interface are determined for each reception path and radio channel. Depending on the result of the evaluation in the evaluation device AW in the base station BS, the signals to be sent in the downlink direction are switched to a respective one of the antenna devices A1 or A2. For example, in the timeslot ts12 intended for the downlink direction in the first frame fr1, the base station BS sends signals via the first antenna unit A1 in the radio channel identified by the first CDMA code c1, if it has been found that the transmission characteristics for the first antenna device A1 are better (shaded areas). For example, the characteristic values can be determined in each frame fr1 to fr4. In this case, the antenna device A1 is used for transmission in each frame fr1 to fr4 for this radio channel in the example.

For the radio channel identified by the third CDMA code c3, characteristic values are determined for both reception paths, whose difference does not exceed a predetermined threshold value. In order to exploit this situation to obtain advantageous decorrelation of signals in two successive frames fr1, fr2, the signals in the radio channel are each switched alternately to the second antenna device A2 and to the first

antenna device A1, as illustrated in the diagram. In addition, the diagram shows a sequence of changing the timeslots ts between the individual frames fr1 to fr4, which can also be referred to as a timeslot hopping method. In this case, the timeslot ts respectively used for the uplink direction and downlink direction is changed according to a predetermined algorithm or time sequence while retaining the CDMA code c, thus reducing the effect on the reception quality of interference which in each case occurs only in specific timeslots ts.

Although other modifications and changes may be suggested by those skilled in the art, it is the intention of the inventors to embody within the patent warranted hereon all changes and modifications as reasonably and properly come within the scope of their contribution to the art.

ABSTRACT OF THE DISCLOSURE

A method and apparatus for signal transmission via a radio interface in a radio communications system in which a radio channel is assigned for signal transmission between a first and a second radio station. A signal is first transmitted via a minimum of two transmission paths. Subsequently, a characteristic value relating to the transmission conditions on the radio interface is determined for each of the transmission paths. A control signal is then derived based on a comparison of the characteristic value among the transmission paths. Subsequently, based on this control signal the optimal transmission path is selected for the upcoming signal transmissions.

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Description

Method and radio station for signal transmission in a radio communications system

The invention relates to a method and a radio station for signal transmission in a radio communications system, in particular in a mobile radio system.

In radio communications systems, information such as voice, video information or other data is or are transmitted by means of electromagnetic waves via a radio interface between a transmitting and a receiving radio station, for example a base station and a mobile station, respectively, in the case of a mobile radio system. The electromagnetic waves are in this case transmitted at carrier frequencies which are in the frequency band intended for the respective system. The carrier frequencies for the GSM mobile radio system (Global System for Mobile Communication) are in the 900 MHz, 1 800 MHz and 1 900 MHz bands. Carrier frequencies in the band around 2 000 MHz are intended to be used for future mobile radio systems using CDMA and TD/CDMA transmission methods via the radio interface, such as the UMTS (Universal Mobile Telecommunication System) or other 3rd generation systems.

The signals to be transmitted are produced in a transmitting devices in the radio station. The transmission signals are supplied via cable links and various other devices such as preamplifiers etc. to an antenna device which, in the end, transmits the radio signals. The transmitted radio signals are received and evaluated by a receiving devices in the received radio station.

In real operational conditions for radio communications systems, the radio signals are subject to widely differing types of interference and reach the receiving device on very different propagation paths. Apart from a direct propagation path, the radio signals can also be reflected or refracted on obstructions such as mountains, trees, buildings and the like. The radio signals from the various propagation paths are superimposed in the receiving device. This leads to cancellation effects which at times have a severe adverse effect on reception of the radio signals, in this context refer to J.D. Parsons, "The Mobile Radio Propagation Channel", Pentech Press Publishers, London, 1992, pages 108-113.

Various methods are known for overcoming these cancellation effects, which are also referred to as fading effects. These fading effects can be reduced by antenna diversity, that is to say by using a number of antennas for the transmitting and/or receiving device. However, since the use of antenna diversity means an increase in the costs and complexity in the base station and in the mobile station of a mobile radio system, antenna diversity has so far been used only in the base stations.

Furthermore, it is known from the GSM mobile radio system for the reception conditions to be improved by using a frequency hopping method (FH), that is to say changing the transmission frequency for the radio signals (M. Mouly, M.B. Pautet, "The GSM System for Mobile Communications", 1992, inter alia, pages 218-223). Furthermore, methods and devices are known from the prior art according to the documents DE 44 32 928, WO 93/20625 and WO 95/32558 which use a combination of a frequency hopping method and an antenna diversity method. Apart from complex implementation, these methods have the disadvantage that they cannot be used for the broadband 3rd generation mobile radio systems, for which it is predicted

that only one frequency band will in each case be available for the uplink and downlink direction for the FDD method (FDD - Frequency Division Duplex), and one frequency band for the uplink and downlink direction for the TDD method (TDD - Time Division Duplex).

A mobile radio system based on microcells is known from the article by Kondo, Suwa "Linear Predictive Transmission Diversity for TDMA/TDD Personal Communication Systems", IEICE Trans. Commun., Vol. E79-B, No. 10, October 1996, pages 1586-1591, in which the base station makes a linear prediction of the signal strength at the mobile station on the basis of the reciprocity between the uplink and the downlink direction. The base station receives a signal in the uplink direction from the mobile station using reception diversity by means of two antenna devices, and measures the signal strength of the received signal during the reception time. The base station uses these measurements to determine which antenna produces the greatest signal strength at the mobile station location, and the base station then transmits the signal in the downlink direction via the predicted antenna.

The invention is based on the object of specifying a method and a radio station which allow the cancellation effect in future radio communications systems to be reduced. This object is achieved by the method as claimed in the features of the independent patent claim 1, and by the radio station as claimed in the features of the independent patent claim 17. Developments of the invention can be found in the dependent claims.

According to the invention, in the method for signal transmission via a radio interface in a radio communications system as claimed in the independent patent claim 1, which uses a

subscriber separation method to distinguish between signals, in which a radio channel is defined at least by a frequency band and a connection-specific fine structure, at least one radio channel is assigned for signal transmission between a first and a second radio station, and at least one signal is transmitted via at least two transmission paths. At least one characteristic value relating to the transmission conditions on the radio interface is determined for each transmission path. A control signal is derived from a comparison of the mutually corresponding characteristic values, by means of which control signal the transmission path is selected specifically for the radio channel for transmitting a subsequent signal.

This method advantageously offers the capability to determine a characteristic value for each transmission path, in order to carry out an assessment of the transmission conditions for this transmission path. The comparison of the respective characteristic values determined for each transmission path is used to select the most suitable path, and one or more subsequent signals are transmitted on this path. The determination of the characteristic values is carried out separately and specifically for each radio channel, since the transmission conditions may differ depending on the respectively used connection-specific fine structure. In consequence, the special feature of this system, which is that a number of radio channels within one frequency band are used for signal transmission, is taken into account since the optimum transmission path is determined for each radio channel, as a result of which the transmission characteristics are advantageously optimized.

According to a first development of the invention, the signal is sent by the second radio station and is received via at least two antenna devices of the first radio station using

diversity reception. The characteristic values are determined, and the control signal derived, from the signal received by the respective antenna device. The control signal actuates a switching device which switches a subsequent signal specifically for the radio channel to one of the antenna devices of the first radio station. With this refinement, it is possible to determine in the first radio station the antenna device, that is to say the transmission path, via which it is better to receive the signal sent by the second radio station. The result of the reception situation allows conclusions to be drawn on the transmission situation for the first radio station, and advantageously makes it possible to use the switching device to select the antenna device which offers the better transmission quality.

As an alternative to the first development, according to a second development of the invention, the signal is transmitted, separated in time, via in each case one transmission path. Based on this feature, a further refinement of the invention means that the signal which is separated in time is sent by in each case one antenna device of the first radio station, and is received by the second radio station. The characteristic values are determined from the respectively received signal, and the control signal is derived from their comparison. The control signal is used to actuate a switching device, which switches a subsequent signal specifically for the radio channel to one of the antenna devices of the first radio station. This refinement advantageously allows the transmission conditions on the radio interface to be determined in the second radio station if the latter has only one antenna device, and allows the subsequent signals to be switched to one of the antenna devices of the first radio station.

In this case, according to further alternative refinements, the characteristic values determined in the second radio station can be transmitted to the first radio station, which derives the control signal from them and actuates the switching device, or the control signal is derived in the second radio station from the specific characteristic values and this are transmitted to the first radio station, with the control signal actuating the switching device in the first radio station. As a consequence of a further development, the characteristic values and the control signal can advantageously be transmitted using in-band signaling since, in consequence, there is no disadvantageous effect on the transmission capacity of the respective radio channel.

According to a further development of the invention, when a number of radio channels are assigned for signal transmission between the first radio station and the second radio station, the control signal is derived from a comparison of all the mutually corresponding characteristic values intended for the respective radio channels. The control signal is used to select a common transmission path for all the radio channels for the subsequent signals. This method, which is referred to as channel pooling, is known inter alia from the article by J. Mayer, J. Schlee, T. Weber "Protocol and Signalling Aspects of Joint Detection CDMA", PIMRC'97, Helsinki, 1997, pages 867-871. The channel pooling method is used advantageously, for example, in order to allow communications links to be provided with different data rates to and from radio stations, or to allow a number of services to be operated in parallel on one communications link.

As a consequence of a further refinement of the invention, the connection-specific fine structure is formed by a CDMA code. The subscriber separation methods chosen for the third generation mobile radio system UMTS, according to which

a distinction is drawn between subscribers on the basis of the respective CDMA code, advantageously allows a large number of radio channels in one broadband frequency band, and thus high utilization of scarce radio resources. Based on this refinement, a further refinement uses a TD/CDMA method as the subscriber separation method. In this case, a radio channel is defined by a frequency band, a timeslot and a CDMA code. This subscriber separation method can be used particularly advantageously if the signals are transmitted using a TDD method. In this case, the signals are transmitted from the first radio station to the second radio station, and from the second radio station to the first radio station, separated in time, in one frequency band. The refinement according to the invention allows the most suitable transmission path to be determined specifically for each radio channel in a timeslot, and to be used for transmitting subsequent signals.

In addition to the selection of a transmission path, further refinements of the invention allow at least two successive signals to be transmitted, using a TD/CDMA subscriber separation method, with the timeslot being changed and/or with the frequency band being changed, and with the respectively used timeslot or the respectively used frequency band being changed periodically and in synchronism with the time protocol of the subscriber separation method. These refinements have the advantage of increased transmission quality since, in consequence, interference which occurs in specific timeslots or in a specific frequency band interferes with only a small proportion of the transmitted signals, and thus has only a minor effect on reception, as a result of these changes.

As a result of a further advantageous development of the invention, the transmitted signals are received in the first radio station and/or in the second radio station using a joint detection method. This method, which is known inter alia from the article by J. Mayer et. al. already mentioned above, allows the reception quality to be increased advantageously since all the fine structures in use are used for detection of a signal which is coded by means of a connection-specific fine structure.

According to a further refinement of the invention, the characteristic value can be related to a reception level, a bit error rate and/or a value proportional to the signal delay time between the first radio station and the second radio station, and/or to a signal-to-noise ratio. Characteristic values which can be found particularly easily in radio communications systems are the reception level and the bit error rate (which are quoted as scaled values RXLEV, RXQUAL) since, as a rule, they already exist in present-day implementations.

The method according to the invention and the radio station according to the invention will now be explained in more detail with reference to illustrations in the drawings, in which:

Figure 1 shows a block diagram of a radio communications system, in particular of a mobile radio system, and a radio communications system-typical operational environment which is characterized by multi-path propagation,

Figure 2 shows a schematic illustration of the frame structure of the radio interface, and of the construction of a radio block,

Figure 3 shows a block diagram of the radio station according to the invention as a base station and a mobile station in a mobile radio system,

Figure 4 shows a flowchart of the method according to the invention for the radio communications system as shown in Figure 1, and

Figure 5 shows an illustration with respect to time of an example of signal transmission from the point of view of a base station in a mobile radio system.

The radio communications system illustrated in Figure 1 and in the form of a mobile radio system comprises a large number of mobile switching centers MSC, which are networked to one another and produce access to a landline network PSTN. Furthermore, these mobile switching centers MSC are each connected to at least one device RNM for allocating radio resources. Each of these devices RNM in turn allows a connection to be set up to at least one base station BS. Such a base station BS is a radio station which can set up links via a radio interface to other radio stations, for example to mobile stations MS or to stationary terminals. At least one radio cell is formed by each base station BS, and radio stations located in the area of this radio cell are supplied with radio resources. In addition, a number of radio cells can be supplied by each base station BS if sectorization is used or if the cell structures are hierarchical.

In real operational conditions for radio communications systems, radio signals are subject to widely differing types of interference between the base station BS and the mobile station MS, which is mentioned by way of example, and reach the receiving device in the mobile station MS on very different propagation paths. Apart from a direct propagation path, the radio signals can also be reflected or defracted on obstructions such as mountains, trees, buildings or the like. The radio signals from the various propagation paths are superimposed in the receiving device, which leads to cancellation effects which can severely adversely affect reception of the radio signals. The

functionality of the illustrated structure is used by the radio communications system according to the invention.

The frame structure of the radio interface, as it is implemented in the third generation mobile radio system UMTS, is shown in Figure 2. A broadband frequency band, for example with a bandwidth of B = 5 MHz, is split in accordance with a TDMA component into a number of timeslots ts, for example 16 timeslots ts1 to ts16. Each timeslot ts within the frequency band B forms a frequency channel fk. The successive timeslots ts within the frequency band B are broken down in accordance with a frame structure. Thus, for example, 16 timeslots ts1 to ts16 are combined to form a frame fr.

When using a TDD transmission method, some of the timeslots ts1 to ts16 are used for signal transmission in the uplink direction, and some of the timeslots ts1 to ts16 are used for transmission in the downlink direction, with the transmission in the uplink direction taking place, for example, at a time before the transmission in the downlink direction. In-between, there is a switching point SP, by means of which it is possible to vary the number of timeslots which are used for transmission in the uplink direction and the number of timeslots for the downlink direction in a flexible manner. A frequency channel fk for the uplink direction in this case corresponds to the frequency channel fk for the downlink direction. The other frequency channels fk are structured in the same way.

Within the frequency channels fk which are intended for user data transmission, information from a number of communications links is transmitted in radio blocks. These radio blocks for user data transmission are composed of sections with data d, each of which has sections embedded in it containing training sequences tseq1 to tseqn which are known at the reception end. The

data d are spread on a connection-specific basis using a fine structure, a spread code c (CDMA code), so that, for example, n links can be separated by this CDMA component at the reception end.

The spreading of individual symbols of data d with Q chips means that subsections of duration tchip are transmitted within the symbol duration tsym. The Q chips in this case form the individual CDMA code c. A guard time gp is also provided within the timeslot ts, to compensate for different signal delay times on the links for successive timeslots ts.

By way of example, Figure 3 shows two radio stations, which are in the form of a base station BS and a mobile station MS in a mobile radio system. There is a radio link for signal transmission between the two radio stations BS and MS. The base station BS is equipped with two antenna devices A1 and A2 and a transmitting/receiving device TRX, via which it can transmit and receive user and signaling information. An evaluation device AW, which is also provided in the base station BS, is supplied with signals output from the respective reception path of the two antenna devices A1 and A2, and characteristic values relating to the transmission conditions of the radio interface are in each case determined from them. Such characteristic values, which may be obtained only after internal conversions in the evaluation device AW, are, for example, the reception lever RXLEV, a scaled variable relating to the bit error rate RXQUAL, a lead time ta or a signal-to-noise ratio C/I. The characteristic values RXLEV, RXQUAL can be signaled, for example, by the mobile station MS as in the GSM mobile radio system, while the details relating to the signal delay time can be obtained in the form of the lead time ta, and the details relating to the signal-to-noise ratio C/I

can be obtained from the received signals in the base station BS itself.

The characteristic values determined for the respective reception path are supplied to a control device SE which is connected downstream of the evaluation device AW and carries out a comparison of respectively mutually corresponding characteristic values. The control device SE uses this comparison to derive a control signal stsig and thus actuates a switching device UE which switches signals to be sent in radio channels downstream of the transmitting/receiving device TRX to one of the antenna devices A1 or A2. In this case, the signals can be switched independently for transmission and reception, that is to say the signals sent by the mobile station MS are, for example, received via both antenna devices A1 and A2 and are supplied to the transmitting/receiving device TRX. This is used advantageously according to the invention if the reception of the radio channels in the base station BS takes place using a joint detection method.

Various scenarios are feasible for determining the characteristic values and for deriving the control signal stsig. According to a first example, this can be done by the mobile station MS sending a signal in an assigned radio channel, with this signal being received by the two antenna devices A1 and A2 using a diversity principle. The evaluation device AW uses this received signal to determine the respective characteristic values for the subsequent determination of which transmission path and which antenna device A1 or A2 offers the better transmission conditions. This determination process related to reception allows the transmission situation to be deduced, since the transmission conditions are generally identical for transmission and reception. The control device

SE in the base station BS selects that antenna device A1 or A2 via which signals are then sent in the downlink direction in the same radio channel.

A second example indicates a further option. In this case, a signal is in each case transmitted in a radio channel to the mobile station MS, separated in time, by the base station BS. Time separation is required since the mobile station MS has only one antenna device A3 and is thus unable to receive two signals in the same radio channel at the same time. The mobile station MS is in this case equipped with an evaluation device AW in which it can determine characteristic values relating to the transmission conditions on the respective transmission path. These characteristic values which have been determined are then sent by the mobile station MS, for example via in-band signaling, to the base station BS, in which the values are supplied to the control device SE which uses them to derive the control signal stsig for actuating the switching device UE.

According to a third example, the mobile station MS may also be equipped with a control device SE, using which it derives a control signal stsig directly from the characteristic values determined in the evaluation device AW, and transmits this control signal stsig to the base station BS, with the switching device UE being actuated by this control signal stsig.

Furthermore, it is feasible for characteristic values relating to the transmission conditions for the radio channel to be determined both in the base station BS and in the mobile station MS, and for these values to be supplied to the control device SE in the base station BS, which means that it is possible to make a more accurate estimate

of the actual transmission conditions on the radio interface.

The characteristic values should be determined separately for each radio channel in a timeslot in a radio communications system having TD/CDMA subscriber separation, since the different CDMA spread codes c, as a result of which the radio channels in a timeslot ts differ, mean that different transmission conditions may also occur. In the situation where a number of radio channels are assigned in one timeslot ts for signal transmission between the base station BS and the mobile station MS, for example using the channel pooling principle as has already been explained in the introduction to the description, characteristic values are determined separately for each radio channel and signals which in each case have to be sent from the base station BS are sent via the antenna device A1 or A2 which has the better transmission conditions. During the process of assigning radio channels in a timeslot ts to a number of mobile stations MS, this refinement means that the best transmission path is selected for each radio channel. Depending on the selected antenna device A1, A2 via which subsequent signals will be sent in the respective radio channel, the transmission power for each timeslot ts and CDMA code c can be controlled separately, as it were.

The method according to the invention can also be applied, for example, in the same way to CDMA subscriber separation methods, in which a radio channel is in each case defined by the frequency band B and a CDMA code c. In this case, characteristic values are in each case determined and a transmission path for the radio channel is selected, for example, at periodic time intervals.

The method according to the invention can be simplified in that, for example, a number of radio channels which have been assigned to a single communications link between the base station BS and a mobile station MS on the channel pooling principle are each sent via only one antenna device A1 or A2 of the base station BS if the differences in the transmission conditions on the basis of the different CDMA code c are not significant. This likewise simplifies the process of controlling the transmission power for transmission to the individual mobile stations MS.

If it is found during the process of determining the characteristic values for the reception paths that the difference between the respectively determined characteristic values for the two reception paths of the antenna device A1, A2 is not greater than a predetermined threshold value, that is to say the transmission conditions for both paths are, for example, virtually identical, protected signal transmission can be achieved by periodically changing between the antenna device A1, A2 when the base station BS is transmitting. This results in successive, decorrelated signals at the mobile station MS location, thus advantageously improving the transmission quality when interference is present on the radio interface.

For additional decorrelation of successive signals, it is also possible, for example, to change the timeslot ts while maintaining the assigned CDMA code c if transmission problems occur repeatedly in specific timeslots ts. A further option, in the situation where a number of frequency bands B are available to the radio communications system, is to change between the frequency bands B using a type of frequency hopping method.

Figure 4 shows an example of a flowchart for one refinement of the method according to the invention. By way of example, in the flowchart block identified by the number 1, a signal is sent via the radio interface between from the mobile station MS to the base station BS. The transmitted signal is transmitted, for example, in an assigned radio channel. The block identified by 2 represents reception of the transmitted signal in the base station BS via two antenna devices A1 and A2 using diversity reception. According to the blocks 3 and 4, the signal received via the respective antenna device A1 and A2 is used to determine characteristic values relating to the transmission conditions on the radio interface for the respective transmission paths. The characteristic values which are determined and correspond to one another are compared with one another in the block 5, and this can be done, for example, in an evaluation device AW in the base station BS. The decision resulting in the selection of the better transmission conditions is made in the decision block 6 depending on the type of characteristic values. If the transmission conditions for the transmission path via the first antenna device A1 are better than the transmission conditions via the second antenna device A2, then, in the block 7, the signals to be sent subsequently are switched in the radio channel via the first antenna device A1 to the mobile station MS. If, on the other hand, the transmission conditions via the second antenna device A2 are better, then, as shown in block 8, signals to be sent subsequently by the base station BS are sent via the second antenna device A2.

In addition to the procedure shown in Figure 4, the sequence can be supplemented, for example, by checking the difference between the specific characteristic values of the

reception paths. Provided this difference is not greater than a predetermined threshold value, then signals to be sent subsequently are alternately switched to in each case one antenna device A1 or A2 using an antenna hopping method, thus advantageously decorrelating the transmitted signals. The evaluation of the signals sent by the mobile station MS can in this case be controlled by a timer, which is matched to the subscriber separation method and/or is synchronized with it.

Figure 5 shows a three-dimensional diagram in which, by way of example, signal transmission according to the invention is carried out in a radio communications system having TD/CDMA subscriber separation and in which the uplink and downlink directions are separated using a TDD method. Firstly, the time t is plotted in the horizontal plane and is split into frames fr1 to fr4 using the TDMA subscriber separation method. Each frame fr1 to fr4 is subdivided into, for example, 16 timeslots ts1 to ts16. As has already been explained with reference to Figure 2, the uplink and downlink directions are separated by a switching point SP, so that transmission takes place in both the uplink direction and the downlink direction within one frame fr. Furthermore, a distinction on the basis of the CDMA code c is made in the horizontal plane. By way of example, four possible CDMA codes c1 to c4 are shown, which allow separation into four radio channels within one timeslot ts when using a frequency band b. In the vertical direction, two antenna devices A1 and A2 are shown, by way of example, via which the signals can be sent from the base station BS.

The example shown in Figure 5 is based on two radio channels being assigned to a communications link between a base station BS, which has two antenna devices A1 and A2, and a mobile station MS, using the channel pooling

principle. The diagram in this case shows the processes of reception and transmission from the point of view of the base station BS. This configuration, which is illustrated by way of example, corresponds to Figure 3. In the initial situation, the allocated radio channels are defined in the first frame fr1 by the timeslot ts4 for the uplink direction and by the timeslot ts12 for the downlink direction, and by the CDMA codes c1 and c3 as well. Accordingly, in the first frame fr1, the mobile station MS sends signals in the uplink direction in the timeslot ts4, using the CDMA codes c1 and c3, to the base station BS. The transmitted signals are received via the antenna devices A1 and A2 in the base station BS, and characteristic values relating to the respective transmission conditions on the radio interface are determined for each reception path and radio channel. Depending on the result of the evaluation in the evaluation device AW in the base station BS, the signals to be sent in the downlink direction are switched to a respective one of the antenna devices A1 or A2. For example, in the timeslot ts12 intended for the downlink direction in the first frame fr1, the base station BS sends signals via the first antenna unit A1 in the radio channel identified by the first CDMA code c1, if it has been found that the transmission characteristics for the first antenna device A1 are better (shaded areas). For example, the characteristic values can be determined in each frame fr1 to fr4. In this case, the antenna device A1 is used for transmission in each frame fr1 to fr4 for this radio channel in the example.

For the radio channel identified by the third CDMA code c3, characteristic values are determined for both reception paths, whose difference does not exceed a predetermined threshold value. In order to exploit this situation to obtain advantageous decorrelation of signals in two successive frames fr1, fr2, the signals in the

radio channel are each switched alternately to the second antenna device A2 and to the first antenna device A1, as is illustrated in the diagram. In addition, the diagram shows a sequence of changing the timeslots ts between the individual frames fr1 to fr4, which can also be referred to as a timeslot hopping method. In this case, the timeslot ts respectively used for the uplink direction and downlink direction is changed in accordance with a predetermined algorithm or time sequence while retaining the CDMA code c, thus reducing the effect on the reception quality of interference which in each case occurs only in specific timeslots ts.

Patent claims

1. A method for signal transmission via a radio interface in a radio communications system, which

- uses a subscriber separation method to distinguish between signals, with a radio channel being defined at least by a frequency band (B) and a connection-specific fine structure (c),

in which

- at least one radio channel is assigned for signal transmission between a first radio station (BS) and a second radio station (MS),
- at least one signal is transmitted via at least two transmission paths,
- at least one characteristic value (RXLEV, RXQUAL, ta, C/I) relating to the transmission conditions on the radio interface is determined for each transmission path,
- a control signal (stsig) is derived from a comparison of the mutually corresponding characteristic values (RXLEV, RXQUAL, ta, C/I), by means of which control signal (stsig) the transmission path is selected specifically for the radio channel for transmitting a subsequent signal.

2. The method as claimed in claim 1, in which

- the signal is sent by the second radio station (MS) and is received via at least two antenna devices (A1, A2) of the first radio station (BS) using diversity reception,
- the characteristic values (RXLEV, RXQUAL, ta, C/I) are determined from the signal received by the respective antenna device (A1, A2), and
- the control signal (stsig) which is derived from the comparison of the mutually corresponding characteristic values (RXLEV, RXQUAL, ta, C/I) is used to actuate a switching device (UE)

which switches a subsequent signal specifically for the radio channel to one of the antenna devices (A1, A2) of the first radio station (BS).

3. The method as claimed in claim 1, in which the signal is transmitted, separated in time, via in each case one transmission path.

4. The method as claimed in claim 3, in which

- the signal which is separated in time is sent by in each case one antenna device (A1, A2) of the first radio station (BS) and is received by the second radio station (MS),
- the characteristic values (RXLEV, RXQUAL, ta, C/I) are determined from the respectively received signal, and
- the control signal (stsig) is derived from the comparison of the mutually corresponding characteristic values (RXLEV, RXQUAL, ta, C/I) and is used to actuate a switching device (UE) which switches a subsequent signal specifically for the radio channel to one of the antenna devices (A1, A2) of the first radio station (BS).

5. The method as claimed in claim 4, in which the specific characteristic values (RXLEV, RXQUAL, ta, C/I) [lacuna] transmitted to the first radio station (BS), and the control signal (stsig) is derived from them.

6. The method as claimed in claim 4, in which the control signal (stsig) is derived in the second radio station (MS) and is transmitted to the first radio station (BS).

7. The method as claimed in claim 5 or 6, in which the characteristic values (RXLEV, RXQUAL, ta, C/I) and the control signal (stsig) are transmitted using in-band signaling.

8. The method as claimed in one of the preceding claims, in which

- when a number of radio channels are assigned for signal transmission between the first radio station (BS) and the second radio station (MS), the control signal (stsig) is derived from a comparison of all the respectively specific and mutually corresponding characteristic values (RXLEV, RXQUAL, ta, C/I), and
- the control signal (stsig) is used to select a common transmission path for all the radio channels for transmission of subsequent signals.

9. The method as claimed in one of the preceding claims, in which in the situation where any difference between the specific and mutually corresponding characteristic values (RXLEV, RXQUAL, ta, C/I) does not exceed a predetermined threshold value, a transmission path is in each case selected on a periodically changing basis, so that at least two successive, decorrelated signals are transmitted via different transmission paths.

10. The method as claimed in one of the preceding claims, in which the connection-specific fine structure is formed by a CDMA code (c).

11. The method as claimed in claim 10, in which a TD/CDMA method is used as the subscriber separation method, with a radio channel being defined by a frequency band (B), a timeslot (ts) and a CDMA code.

12. The method as claimed in one of claims 11, in which the signals are transmitted using a TDD method, in which the signals are transmitted from the first radio station (BS) to the second radio station (MS) and from the second radio station

(MS) to the first radio station (BS), separated in time, in one frequency band (B).

13. The method as claimed in claim 11 or 12, in which at least two successive signals are transmitted with the timeslot (ts) being changed, with the timeslot (ts) which is used for transmission being changed periodically and in synchronism with the time protocol of the subscriber separation method.

14. The method as claimed in one of the preceding claims, in which at least two successive signals are transmitted with the frequency band (B) being changed, with the frequency band (B) which is used for transmission being changed periodically and in synchronism with the time protocol of the subscriber separation method.

15. The method as claimed in one of the preceding claims, in which the transmitted signals are received in the first radio station (BS) and/or in the second radio station (MS) using a joint detection method.

16. The method as claimed in one of the preceding claims, in which a reception level, a bit error rate and/or a value proportional to the signal delay time (ta) between the first radio station (BS) and the second radio station (MS), and/or a signal-to-noise ratio is defined as the characteristic value (RXLEV, RXQUAL, ta, C/I).

17. A radio station (BS, MS) for signal transmission via a radio interface in a radio communications system, which

- uses a subscriber separation method to distinguish between signals, in which a radio channel is defined at least by a

frequency band (B) and a connection-specific fine structure (c),

having

- at least one antenna device (A1, A2) for receiving and/or sending at least one signal which is transmitted via at least two transmission paths,
- an evaluation device (AW) for determining at least one characteristic value (RXLEV, RXQUAL, ta, C/I) relating to the transmission conditions on the radio interface for each transmission path,
- a control device (SE) for deriving a control signal (stsig) from a comparison of the mutually corresponding characteristic values (RXLEV, RXQUAL, ta, C/I), and
- a switching device (UE) which is actuated by the control signal (sig) and selects the transmission path specifically for the radio channel for transmitting a subsequent signal.

18. The radio station (BS, MS) as claimed in claim 17,
which is designed as a base station in a mobile radio system.

19. The radio station (BS, MS) as claimed in claim 17,
which is designed as a mobile station in a mobile radio system.

Abstract

Method and radio station for signal transmission in a radio communications system

In the method for signal transmission via a radio interface in a radio communications system, at least one radio channel is assigned for signal transmission between a first and a second radio station, and at least one signal is transmitted via at least two transmission paths. At least one characteristic value relating to the transmission conditions on the radio interface is determined for each transmission path. A control signal is derived from a comparison of the mutually corresponding characteristic values, by means of which control signal the transmission path is selected specifically for the radio channel for transmitting a subsequent signal.

Figure 3

09/701668

FIG 1

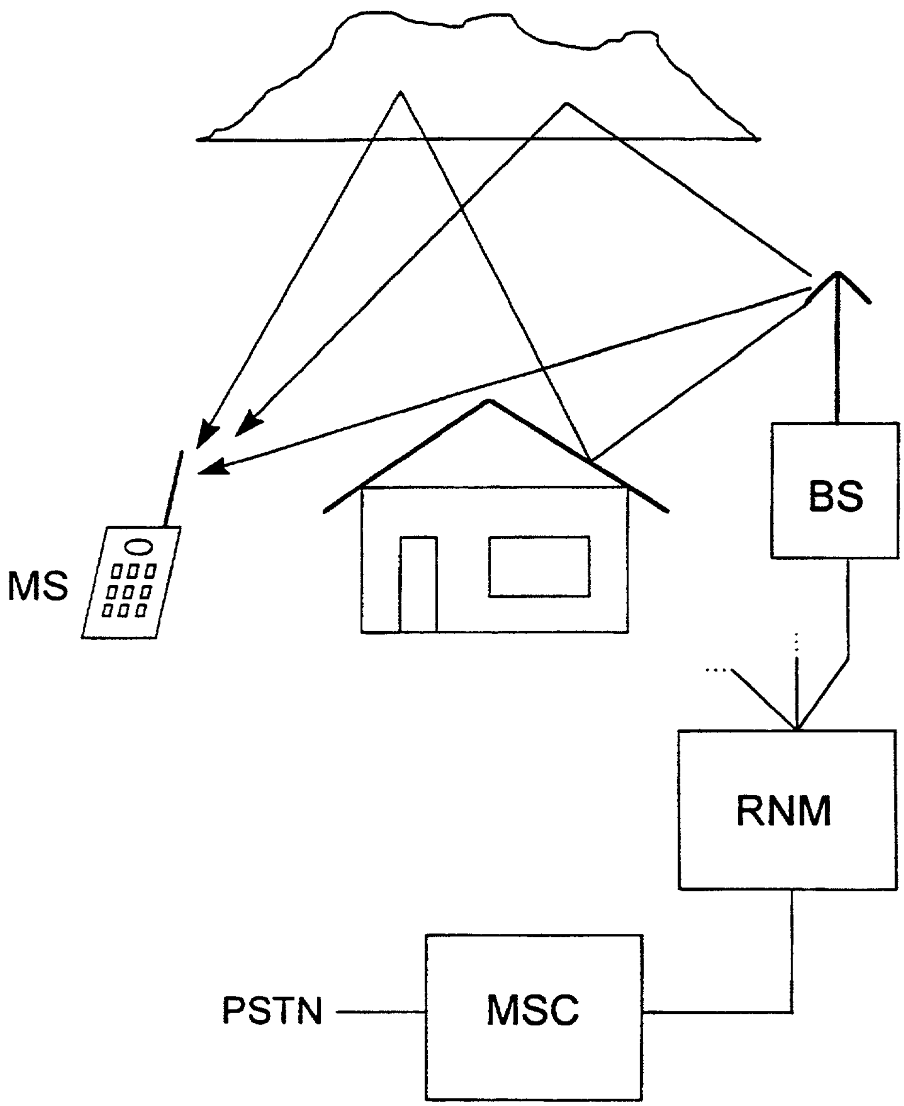


FIG 2

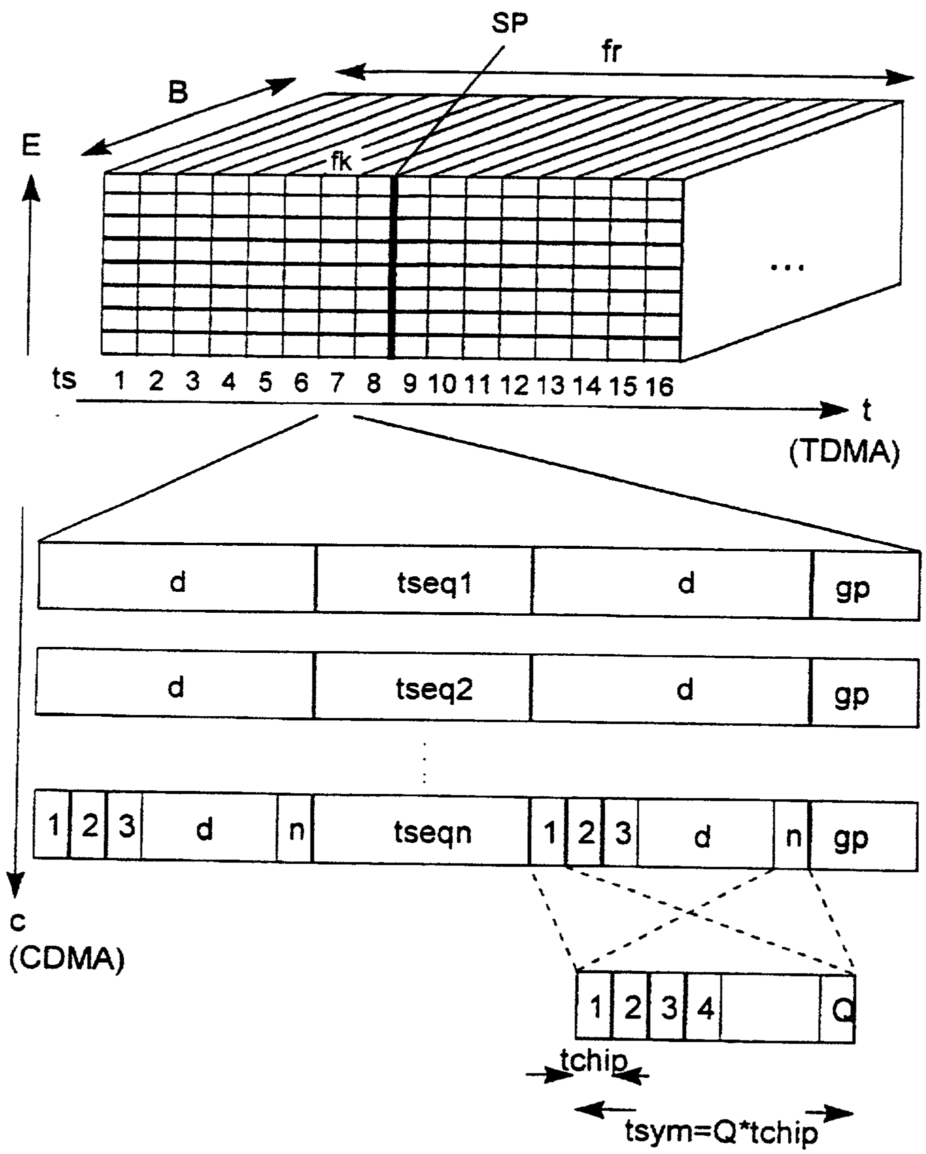

SP
fr
B
E
fk
...
ts
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
t
(TDMA)
d
tseq1
d
gp
d
tseq2
d
gp
1 2 3 d n tseqn 1 2 3 d n gp
c
(CDMA)
1 2 3 4 Q
tchip
tsym=Q*tchip

FIG 3

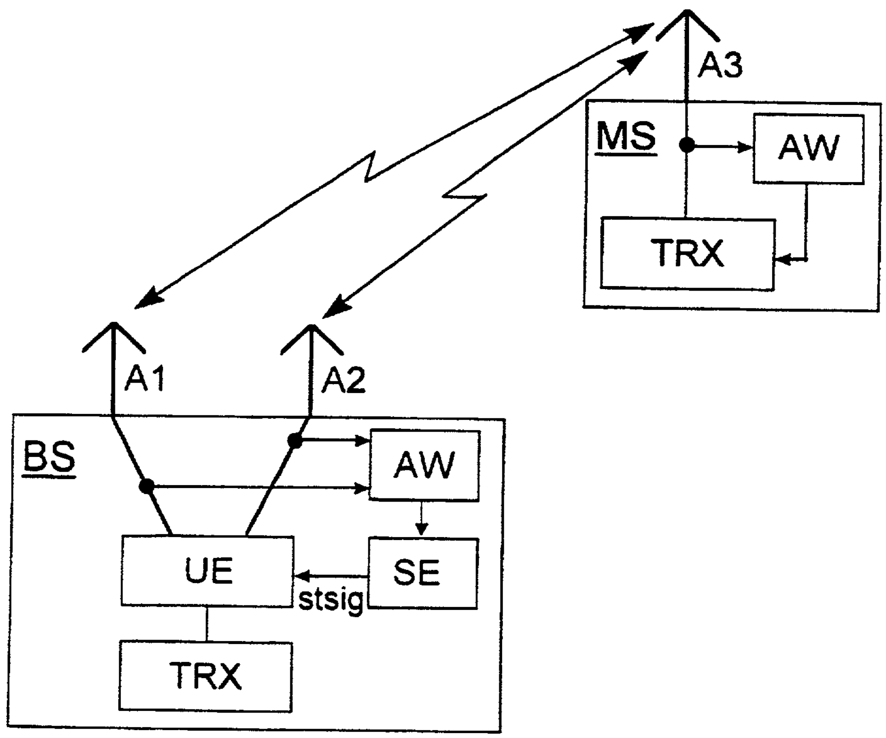


FIG 4

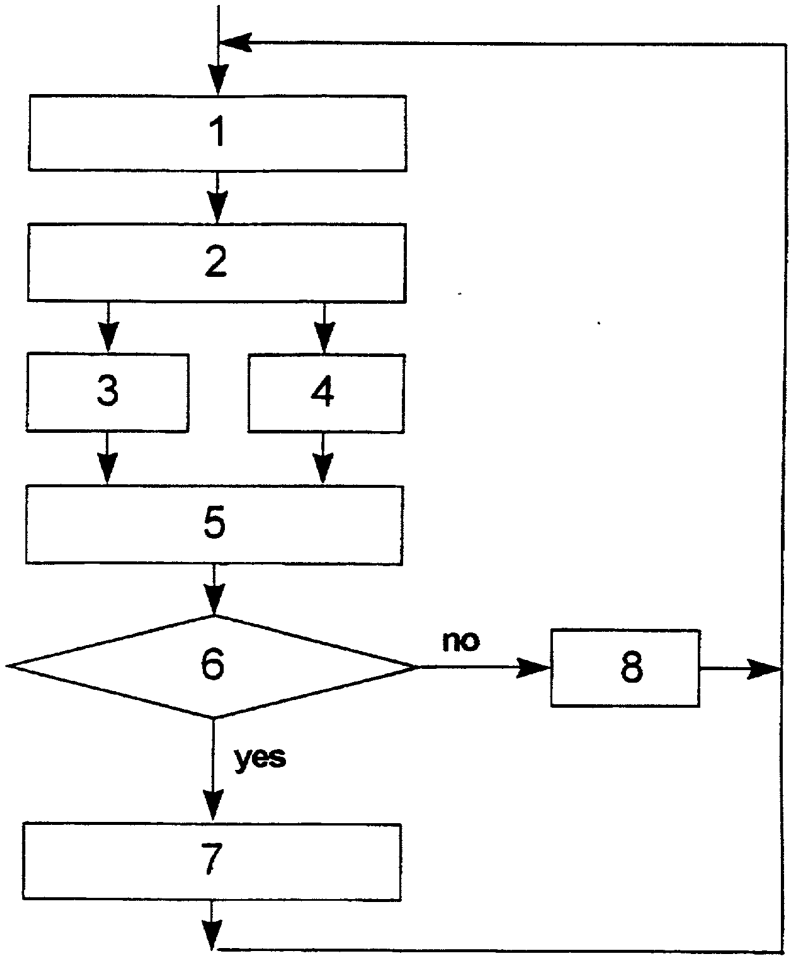
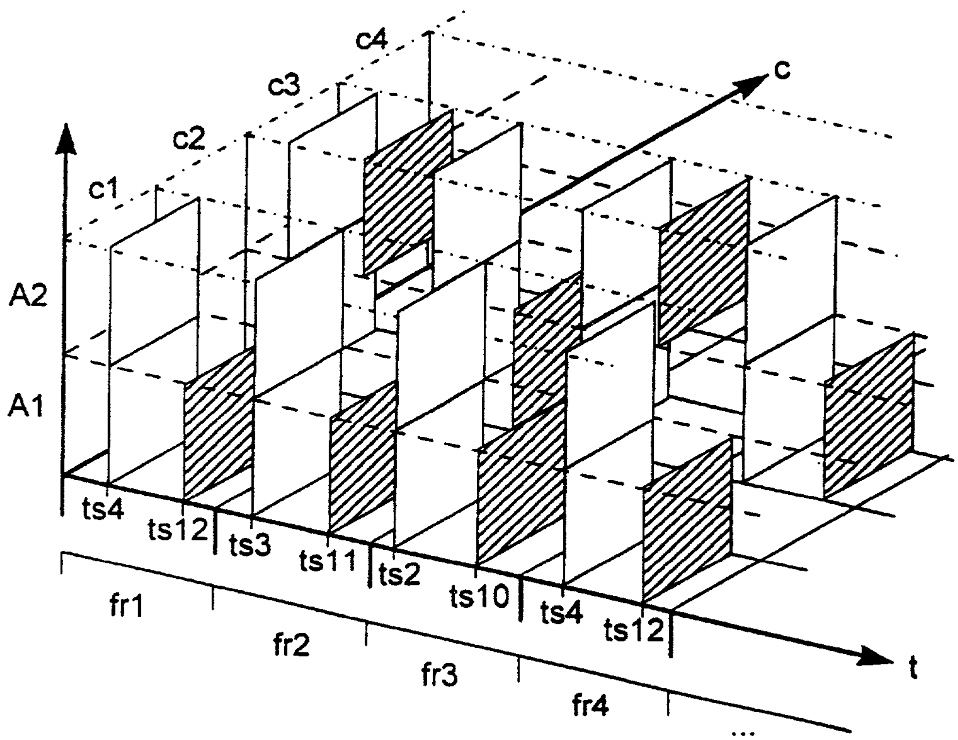


FIG 5


c4
c3
c2
c1
c
A2
A1
ts4
ts12
ts3
ts11
ts2
ts10
ts4
ts12
t
fr1
fr2
fr3
fr4
...

Declaration and Power of Attorney For Patent Application

Erklärung Für Patentanmeldungen Mit Vollmacht

German Language Declaration

Als nachstehend benannter Erfinder erkläre ich hiermit an Eides Statt:

As a below named inventor, I hereby declare that:

dass mein Wohnsitz, meine Postanschrift, und meine Staatsangehörigkeit den im Nachstehenden nach meinem Namen aufgeführten Angaben entsprechen,

My residence, post office address and citizenship are as stated below next to my name,

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I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Verfahren und Funkstation zur Signalübertragung in einem Funk-Kommunikationssystem

____

deren Beschreibung

the specification of which

(zutreffendes ankreuzen)

(check one)

☒ hier beigefügt ist.

☐ is attached hereto.

☐ am ______________ als PCT internationale Anmeldung PCT Anmeldungsnummer ______________ eingereicht wurde und am ______________ abgeändert wurde (falls tatsächlich abgeändert).

☐ was filed on ______________ as PCT international application PCT Application No. ______________ and was amended on ______________ (if applicable)

Ich bestätige hiermit, dass ich den Inhalt der obigen Patentanmeldung einschliesslich der Ansprüche durchgesehen und verstanden habe, die eventuell durch einen Zusatzantrag wie oben erwähnt abgeändert wurde.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims as amended by any amendment referred to above.

Ich erkenne meine Pflicht zur Offenbarung irgendwelcher Informationen, die für die Prüfung der vorliegenden Anmeldung in Einklang mit Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) von Wichtigkeit sind, an.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

Ich beanspruche hiermit ausländische Prioritätsvorteile gemäss Abschnitt 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 119 aller unten angegebenen Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde, und habe auch alle Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde nachstehend gekennzeichnet, die ein Anmeldedatum haben, das vor dem Anmeldedatum der Anmeldung liegt, für die Priorität beansprucht wird.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

German Language Declaration

Prior foreign appplications
Priorität beansprucht

			Priority Claimed	
198 24 152.6	Germany	29. Mai 1998	☒	☐
(Number) (Nummer)	(Country) (Land)	(Day Month Year Filed) (Tag Monat Jahr eingereicht)	Yes Ja	No Nein
			☐	☐
(Number) (Nummer)	(Country) (Land)	(Day Month Year Filed) (Tag Monat Jahr eingereicht)	Yes Ja	No Nein
			☐	☐
(Number) (Nummer)	(Country) (Land)	(Day Month Year Filed) (Tag Monat Jahr eingereicht)	Yes Ja	No Nein

Ich beanspruche hiermit gemäss Absatz 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 120, den Vorzug aller unten aufgeführten Anmeldungen und falls der Gegenstand aus jedem Anspruch dieser Anmeldung nicht in einer früheren amerikanischen Patentanmeldung laut dem ersten Paragraphen des Absatzes 35 der Zivilprozeßordnung der Vereinigten Staaten, Paragraph 122 offenbart ist, erkenne ich gemäss Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) meine Pflicht zur Offenbarung von Informationen an, die zwischen dem Anmeldedatum der früheren Anmeldung und dem nationalen oder PCT internationalen Anmeldedatum dieser Anmeldung bekannt geworden sind.

I hereby claim the benefit under Title 35. United States Code. §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §122, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occured between the filing date of the prior application and the national or PCT international filing date of this application.

(Application Serial No.) (Anmeldeseriennummer)	(Filing Date) (Anmeldedatum)	(Status) (patentiert, anhängig, aufgegeben)	(Status) (patented, pending, abandoned)
(Application Serial No.) (Anmeldeseriennummer)	(Filing Date) (Anmeldedatum)	(Status) (patentiert, anhängig, aufgeben)	(Status) (patented, pending, abandoned)

Ich erkläre hiermit, dass alle von mir in der vorliegenden Erklärung gemachten Angaben nach meinem besten Wissen und Gewissen der vollen Wahrheit entsprechen, und dass ich diese eidesstattliche Erklärung in Kenntnis dessen abgebe, dass wissentlich und vorsätzlich falsche Angaben gemäss Paragraph 1001, Absatz 18 der Zivilprozessordnung der Vereinigten Staaten von Amerika mit Geldstrafe belegt und/oder Gefängnis bestraft werden koennen, und dass derartig wissentlich und vorsätzlich falsche Angaben die Gültigkeit der vorliegenden Patentanmeldung oder eines darauf erteilten Patentes gefährden können.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

And I hereby appoint

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2-00

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7-00

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Staatsangehörigkeit	Citizenship
Postanschrift	Post Office Address

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Staatsangehörigkeit	Citizenship
Postanschrift	Post Office Address

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Staatsangehörigkeit	Citizenship
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